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THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

· APRIL · 1915 ·

SPRING MEETING, BUFFALO, JUNE 22-25

THE HUMAN ELEMENT

THE Human Element is probably the most neglected as well as the most important element in the complex work of the engineering profession. While dealing with iron and steel, steam, electricity, gas, concrete and other materials, engineers have been overlooking *personality*, which is the essence of engineering. We have been engineers of things as distinguished from engineers of men.

The Society supplies the Human Element in engineering. It brings men together—brings their ideas together—the East with the West—the North with the South—America with other nations. The older men keep in touch with one another; the younger men have a chance to meet the veterans. The Society helps them to *know* each other, and each profits by the experience.

Every member can participate in this work.

One of the Society's activities which is opportune just at present, is placing desirable men in desirable positions.

Members are earnestly requested to advise the Society of opportunities and to inform their employers and friends that the Society is prepared to suggest men of proven ability in the various specialties of the profession.

TRY SOCIETY SERVICE

The service is free, but is restricted to members

Total Membership of the Society, March 25, 1915	6199
New Members since January 1, 1915	89

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 April 1915 Number 4

THE SPRING MEETING

ARRANGEMENTS are progressing satisfactorily for the coming Spring Meeting which is to be held in Buffalo from the 22nd to the 25th of June. This date follows the commencement season at the colleges, so that many who are connected with the work of the technical schools of the country will be able to attend, where heretofore there could be only a very limited representation from any one college.

The local committees at Buffalo have all been appointed and are at work. The chairmen of these committees are as follows: General Committee, David Bell; Finance, D. W. Sowers; Reception, H. P. Parrock; Entertainment, David C. Howard; Hotel, W. H. Carrier; Printing and Publicity, John Younger. The entire membership of The American Society of Mechanical Engineers in Buffalo are to constitute the Reception Committee. The ladies of Buffalo are to appoint several of their number as patronesses to assist the Entertainment Committee at receptions and entertainments for the visiting ladies.

During the three days of the meeting there will be three periods for professional sessions, with probably four sessions, one of which will be in charge of the local engineers at Buffalo in accordance with the usual custom for the Spring Meeting. The papers for the several sessions are well in hand, the larger part of them already having been received by the Committee on Meetings, who regard them as of a very high order. Definite announcement of these will be made in the May issue of The Journal and printed copies will be available, free of cost, for all members who desire them in advance of the meeting.

This is the first meeting of the Society in Buffalo, although it held its convention at Niagara Falls in 1898. Naturally, Niagara Falls with its tremendous storehouse of energy, attracts the attention of engineers the world over; and especially in the electrical and chemical fields, because of the electro-chemical industries made possible there by the great quantity and low cost of power. The City of Buffalo, however, only 20 miles from Niagara Falls, with a population of 500,000, has many and diversified industries equally as interesting to the mechanical engineer. Raw materials, coal, ores and lumber are brought by boat into Buffalo at minimum cost for transportation; and this, with the transmission of power from Niagara Falls, has made possible the great industrial development of the city.

The manufacturing plants include several large steel works, the largest of which is the Lackawanna Steel plant; blast furnaces, foundries, rolling mills for copper and brass, machine tool plants, machine shops manufacturing Diesel engines, steam pumps, steam engines, elevators, gas and gasoline engines, etc.; automobile plants, the new Curtis factory for aeroplanes, manufactories for paints, oils, varnishes, rubber goods, hardware, paper board, etc. It is also a center for the brewing and flour milling industries.

Buffalo, besides, is a city set in a beautiful country with the added attractions of the lake and of Niagara Falls and is at its best in the month of June. Every opportunity will be afforded for the enjoyment of the city and its surroundings, both by the ladies of the party and the visiting engineers.

SAN FRANCISCO MEETINGS

Circulars have been sent to the entire membership relating to the International Engineering Congress for 1915 and the special train arrangements which have been provided.

The International Engineering Congress will be held September 20-25, 1915, in San Francisco, under the auspices of the American societies of civil, mining, mechanical, electrical and marine engineers. In connection with the Congress, The American Society of Mechanical Engineers will hold a meeting on September 16 and 17, the latter part of the week immediately preceding the week of the Congress, so as to enable its members to attend both the meeting of their own Society and of the Congress, and to visit the Panama-Pacific Exposition with the least possible expenditure of time.

During this period the headquarters of The American Society of Mechanical Engineers will be at the

Hotel Clift, with the management of which arrangements should be made direct and at as early a date as possible. A special train will leave New York on Thursday, September 9, arriving in San Francisco on Wednesday, September 15, with stops of several hours at Niagara Falls, Colorado Springs and the Grand Canon. Special arrangements are also planned for those in the South to go by way of New Orleans.

TRIP BY THE SECRETARY

In response to a number of invitations to visit the student engineering societies affiliated with this Society, the Secretary has recently visited Purdue University, Case School of Applied Science, Ohio State University, University of Cincinnati, State University of Kentucky, Virginia Polytechnic Institute, Georgia School of Technology and the Alabama Polytechnic Institute.

The Secretary was particularly pleased to visit Purdue as he had not been able to stop at the University for a number of years. It was not because of lack of interest that no visit had been made, but simply on account of the many demands on the Secretary's time which made more frequent trips impossible. On account of the prominent position which the University takes in research work, particularly in railroad engineering, which is one of the branches of engineering in which the Society takes great interest, there should be a strong section of the Society here and also an active student engineering society. The Secretary was particularly pleased to see on the bulletin boards an announcement of a joint meeting between the student societies of the Mechanical Engineers and of the Electrical Engineers. It is this spirit of coöperation which gives America its preëminence in the world in all activities. It is in this way that, while maintaining commendable rivalry, we omit competitive meetings.

At the University of Cincinnati splendid interest was shown. The men of the engineering society have to meet in the evening and, on account of being in the shops part of the time, the entire section could not meet on the same evening; consequently, the Secretary arranged to meet the students on two different evenings in order to greet them all. A photograph was taken of the members of the section and the section was encouraged to send it to the Society so that a reproduction of it might be given in The Journal.

The members of the Society in Cincinnati and vicinity had a dinner preceding the address in regard to the Society's work which was attended by Mr. Edward Hedden Worthington, a grandson of Henry R. Worthington, the founder of the Society, and also by George Hornung who has been a member of the Society for 30 years.

One of the interesting features in connection with the meeting in Cincinnati was the visit to the rooms of the Engineers Club. Previous to the organization of local sections, the Engineers Club was practically inactive. At no time had as many as 15 of our members been members of the Club. As it is the policy of this Society to encourage in all cities the local engineering society and to make it the center of life for the engineering profession in that locality and to make the branches of the national societies contribute to the success of the local society, it was a source of great satisfaction to learn that Cincinnati had literally carried out the advice of the Society and had revived the Engineers Club with the result that there are now several hundred members, with 50 from our Society active in the organization, and with comfortable rooms in the center of the city open and available from early until late every day in the year.

At the State University of Kentucky, the Society enjoys the unique situation of having every Junior and Senior student in engineering a member of the student engineering society affiliated with The American Society of Mechanical Engineers. The mottos in the office of the dean are indicative of the theme of the address of the Secretary, namely, that the benefits for membership in the Society and in the student engineering societies are in proportion to the investment made by the student.

At Columbus splendid enthusiasm was shown by the men. Our student engineering society has as its officers the leaders in the college athletics and the same merit system prevails with regard to officers of sections as is required in athletics, namely, that no man may be an officer of a section with any demerits in the work of the University.

The Secretary does not want to fail to note the admirable library at Columbus and the enthusiasm of the assistant librarian to carry out the scheme proposed by the librarian of the Engineering Societies, to coöperate in the preparation of a finding list of engineering literature so that students and members in research work will be able to learn in what libraries they can secure sets of periodicals, Transactions and the important works generally.

At the Virginia Polytechnic Institute, Blacksburg, West Virginia, the Secretary was greeted by large posters announcing the meeting of the Society, distributed about the town. The meeting was attended by the entire student body and citizens generally. In the afternoon, the Secretary gave a separate address to the student branch. It was gratifying to have Dean Randolph state that six months after graduation he had joined the Society and that he had now been a member for 31 years and considered it the best investment of his life and a source of continual benefit. It should be remarked in this connection that, notwithstanding the fact that Blacksburg is a little out of the main line, when the interest of the members was aroused recently in the matter of bringing the benefits of membership in the Society to the attention of the engineering pro-

fession, Dean Randolph was successful in reaching a larger number than any other individual member.

At the Alabama Polytechnic Institute, Auburn, the Secretary was given the honor of addressing the entire student body in the presence of the President and the faculty. This was followed in the afternoon by a special address to the engineering students which was so well attended that the audience room was filled to overflowing and men were standing in the halls.

At the Georgia School of Technology similar enthusiasm was shown in the address given in the forenoon before the student body, which was followed by an address in the evening before the affiliated technical societies. A number of the students attended the evening meeting paying $1.00 for the privilege as refreshments were served in connection with the meeting, and notwithstanding that there were three other student engagements scheduled for that evening.

In most places the merit system prevails and the work of the student engineering societies is being conducted on a high plane, direct or indirect credit in the regular school work being given for work in the student branch.

In each city where there are local members a meeting was also arranged. Great enthusiasm was shown, particularly at the universities in the South and at the meeting of the affiliated technical societies in Atlanta. The theme of the Secretary's remarks was the participation of the engineer in public affairs and involved a statement of what the engineer is doing and an encouragement to the engineers to take a great part from a sense of public duty and public service; also, that it is incumbent upon the engineer to acquaint the public with the work of the engineer. Following further statements about the work of the Society and its activities, there was an address illustrated by stereoptican views of the trip of the Society through Germany two years ago, with a description of the Deutsches Museum.

At Atlanta, members of the four national engineering societies, the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers, and the American Chemical Society and the Engineering Society of the South have effected an organization where special emphasis is placed on service to the public, and in this respect so far as the Secretary is advised, this feature is unique in American engineering societies and highly to be commended. In other cities the engineers have gotten together in a splendid way, notably in St. Louis and Boston, where all meetings are coöperative; but in Atlanta they not only have coöperative meetings but, without any desire for position or remuneration, are placing themselves at the disposal of the city administration and in fact insisting on efficient, intelligent work being performed in the matter of smoke abatement, street construction, sewers and garbage disposal, water works, etc., which is obviously the peculiar field of the engineer. In too many cities positions in these departments are filled by men with no peculiar fitness for the work.

HESS PRIZES FOR JUNIOR AND STUDENT MEMBERS

Announcement has already been made in The Journal and Year Book of the generous gift of Mr. Henry Hess, by which the income from $2000 is available for the awarding of prizes for technical papers from Junior and Student Members. The committees of award for these prizes for the coming year have been appointed by the Council, and consist of the following members:

Junior Prizes	*Student Prizes*
R. H. Fernald	F. R. Hutton
Fred E. Rogers	R. H. Fernald
George B. Brand	D. S. Kimball

A statement is made in the first pages of this number of The Journal of the conditions governing the award of prizes and it is hoped that every Junior and Student Member will read these with care and that all who have valuable material which is available for a contribution to the Society will respond to the call and join in the friendly contest by sending such contributions to the Secretary of the Society so that they will be received on or before June 30, 1915.

COUNCIL NOTES

At the meeting of the Council on March 12, 1915, it was voted to approve the following amendment to the By-Laws:

All written reports of all committees shall be presented to the Council. Each written report of every committee must be approved in writing by at least a majority of the members of that committee, before it is presented to the Council. A member of a committee who disagrees with the action of a majority of that committee may express his disagreement over his signature either on the report of the committee or in a minority report. The minority report of any member of a committee, if offered, shall be presented at the same time that the report of that committee is presented to the Council.

All reports of committees must be first received by the Council who shall prescribe the manner in which they shall be presented to the Membership of the Society and be made public and printed.

It was voted that the portion of the Boiler Code report entitled "Rules for the Construction of Stationary Boilers and for Allowable Working Pressures," already received by the Council, be copyrighted as a preprint of Transactions. It was voted, also, that under the So-

ciety's copyright and without compensation to the Society, any legislative body be permitted to print these Rules and distribute officially for the state or municipality over its name.

It was voted that the members of the Council be requested to formulate suggestions for the conduct of professional committees and submit them to Mr. Henry Hess as Chairman of the Engineering Standards Committee, that this committee may have the suggestions in hand for drafting its code of rules.

The Secretary read the following resolution from the meeting of the New York Section held February 9, 1915:

"It is recommended that the Council be asked to appoint a committee to consider the question of the Society undertaking a digest of the material that has appeared in the publications of the Society."

In this connection, a communication from the American Gas Institute was presented requesting coöperation in the matter of a joint committee to obtain a standard system of classification of engineering knowledge.

VOTED: that the President appoint a committee of five to confer with the Committee of the American Gas Institute and that this committee of the Society also take under consideration the matter of a proposed digest of material that has appeared in the publications of the Society as suggested by the New York section.

VOTED: that R. H. Fernald, Fred E. Rogers and George B. Brand be appointed a committee on the Hess Prize for Junior Members and that F. R. Hutton, R. H. Fernald and D. S. Kimball be appointed a committee on the Hess Prize for Student Members.

CALVIN W. RICE, *Secretary.*

PRICE OF THE BOILER CODE

Since the last number of The Journal, in which was chronicled the completion of the report of the Boiler Code Committee on "Rules for Construction of Stationary Boilers and for Allowable Working Pressures," important action has been taken by the Society with regard to the price to be charged for the Boiler Code and in providing for the use of large editions by the legislative bodies of states and municipalities. The original price charged for copies of the Code was $1.00 to members and $1.50 to non-members. It had been thought that in view of the great amount of work that had been expended on the Code, not only by the Committee members but also by the office staff of the Society; and because of the great expense to which the Society had been in printing and handling the preliminary reports of the Committee (approximately $6000), these prices were equitable and reasonable.

It is generally recognized, however, that the primary object of this report is not to reimburse the Society; on the contrary, the report has been prepared for the public good and it is undoubtedly destined to accomplish this end to a greater extent than any other publication which the Society has issued. Its greatest usefulness will not be attained until it becomes a standard in general use throughout the country, and the Society desires to do its utmost to bring about this most desirable accomplishment. It has therefore been decided to establish a scale of prices which shall not only be equitable to the membership of the Society, but attractive as well to legislative bodies.

For sales in limited numbers the same rate will be charged as for all of the reprints issued in pamphlet form by the Society, namely 5 cents per sixteen pages or fraction thereof, to members, and 10 cents to non-members, making the cost of the Code 40 cents to members and 80 cents to non-members on individual orders. For large editions for the use of legislative bodies and municipalities the price has been placed low enough to make it an inducement for ordering direct from the Society rather than to have it reprinted elsewhere, for one of the most important factors to be considered in the introduction of the Code is its accuracy. If the various legislative bodies that use the Code should have it printed by different printing establishments, with non-technical and indifferent proofreading, errors would be certain to creep in; while, on the other hand, any arrangement which would make possible the reproduction direct from the Society's type-plates of special editions that might be desired would insure accuracy. Hence the decision to name a price so low for quantity orders that printing from anything else than the Society's plates would in all probability be precluded. As a result the following schedule of prices has been put into effect:

PRICE LIST

For copies of the "Rules for the Construction of Stationary Boilers and for Allowable Pressures."

20 cents per copy in lots of 2000 or over.
30 cents per copy in lots of 1000 to 2000.
F.O.B. Printer, Lyons, N. Y.
40 cents per copy in lots less than 1000, delivered, to members of the Society (and to organizations when shipped to one address).
80 cents for individual orders delivered to non-members of the Society.
Special covers extra on orders of less than 2000.

An important decision in the administration of the Boiler Code was the action of the Council of the Society at its meeting of March 12, to copyright the Code as a reprint of Transactions. This was the result of a desire to protect the Code from undignified usage or inaccurate reproduction, it having been felt that such protection could not be gained in any other way. It was not the purpose, however, to restrict its distribution or limit its usefulness in the direction for which it was primarily intended. In order that legislative bodies might not be limited in any way by the copyright or in fact any restriction be placed on its distribution, a resolution was passed at the same meeting of the Council, as follows:

Resolved: that under the Society's copyright and without compensation to the Society, any legislative body should be permitted to print these Rules and to distribute them officially for the state or municipality over its name.

The completion of the report of the Boiler Code Committee, referred to in the preceding issue of The Journal, marked the inauguration of concerted efforts on the part of organizations of boiler manufacturers and others interested in uniform legislation, looking toward the introduction of the Boiler Code in various states. As announced in that issue, definite steps have been taken in this direction in Wisconsin, Indiana and Ohio. Since then similar action has been taken or proposed in a number of other states, including Michigan, Florida, Pennsylvania, New Jersey, Tennessee, and others. It is also of interest to note the commendatory action of the American Society of Agricultural Engineers at its recent annual meeting with respect to the Code, as evidenced in the following resolutions:

Resolved: that we, the American Society of Agricultural Engineers, assembled in annual meeting, do hereby unanimously approve of the efforts of the American Society of Mechanical Engineers to formulate a code of rules for the construction of steam boilers that may be used as a model by legislative bodies and thus promote uniformity.

Resolved: that we unanimously recommend the adoption of these uniform rules by the various states and municipalities having boiler legislation pending.

VISITS BY DELEGATIONS FROM TECHNICAL COLLEGES

At this time of the year, the Society is privileged to receive visits from colleges of groups of students who are en tour for the inspection of various plants previous to the Commencement exercises which come later in the season. Several such delegations have already called and others are expected for the current year.

One of the largest groups which has visited the Engineering Societies Building and Library is the Senior Class of electrical and mechanical engineers from the Sheffield Scientific School of Yale University. There were 120 students, each with his note-book for recording data connected with his trip. To this group, the librarian explained the manner in which the Library of the United Engineering Societies is endeavoring to serve the engineering public in all parts of this country, and even in other countries, by reference work, the translation of articles, and photographic reproduction of articles where complete transcripts are desired.

After inspecting the headquarters of the three founder societies in the building, the students all gathered in the auditorium for brief addresses by the secretaries of these societies, who spoke of the new and broader vision for the engineer who must in this day not only consider himself an engineer of things but of men; and in so doing have in mind that the greatest results can be secured only by providing the best possible conditions for the workers who may come under their control and by giving their own services freely for the public good—in short, that service is the keynote of the success of the present day engineer.

FREDERICK WINSLOW TAYLOR

Frederick Winslow Taylor, Past-President of The American Society of Mechanical Engineers, died suddenly of pneumonia, in Philadelphia, on March 21.

Mr. Taylor was born in Germantown, Pa., in 1856. He had two years' schooling in Germany and France, and partially prepared for Harvard at Phillips Exeter Academy; but his eyesight became impaired and he had to withdraw from school. He determined, however, to get his education in another way and began an apprenticeship with William Sellers and Company, Philadelphia. In order to make as rapid progress as possible and to get some special advantages, he worked for less pay than the other apprentices, and in four years completed a journeyman's course both in the patternmaker's and the machinist's trade. When he finished his apprenticeship in 1878, times were so dull that he was unable to get work at either of his trades, and he entered the machine shop of the Midvale Steel Company as a laborer.

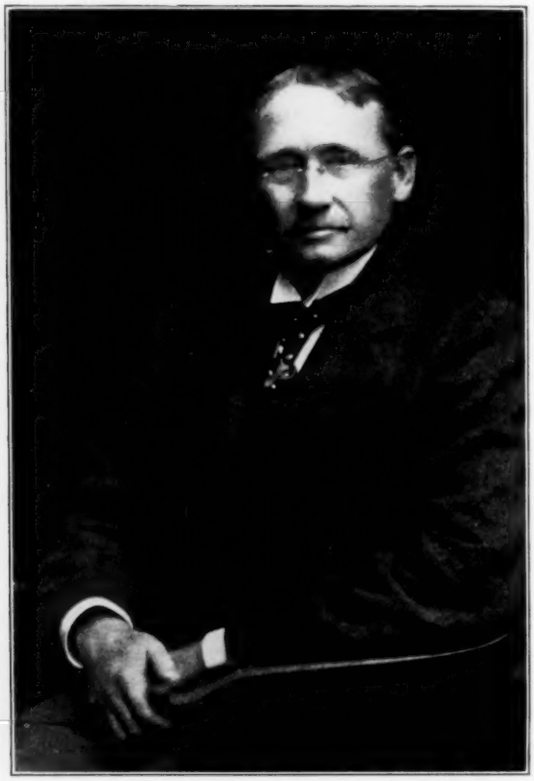
His first promotion was to the position of shop clerk, after which he was given charge of the toolroom. As head of the toolroom he saw the advantage of having all the shop tools ground by one man and instituted this reform, inventing the Taylor grinder for the purpose. From head of the toolroom he became successively gang boss, assistant foreman and then foreman of the machine shop. Next he became master mechanic in charge of repairs and maintenance of the works; then chief draftsman, and in 1884, chief engineer of the works, thus having advanced from laborer to chief engineer in six years.

Soon after he entered Midvale, young Taylor began to feel the need of a better understanding of the underlying principles of the science of engineering, and in 1880, while working ten hours a day, he began to study at night the engineering course of Stevens Institute of Technology, which he completed in 1883, when he received the degree of M.E. This remarkable accomplishment of passing the examinations of such a course as that of Stevens Institute of Technology in the short period of three years, with practically no assistance from any teacher, and while regularly at work, is striking evidence of his superior ability and capacity.

Mr. Taylor remained with the Midvale Steel Company until 1890, during which time he made many improvements in machinery and methods, and filled in a satisfactory manner the successive positions assigned to him. In his passage through the shops he had

studied the management and methods, and had developed his naturally keen powers of observation and ability to analyze and draw deductions. Whenever possible he made direct application of his deductions until the plant as a whole bore the imprint of his labor.

As no definite data were available as to what a mechanic should produce with a given tool and a given piece of work, he began systematic studies of the subject with the coöperation of the shop men, and as a result the output of many tools was increased 200 to 300 per cent with an increase of pay of 25 to 100 per cent to the workmen. Thus during this time he carefully observed and studied the general problem of



FREDERICK WINSLOW TAYLOR

securing higher labor and tool efficiencies and laid the foundation of what later became his specialty, "The development and application of the science of shop organization and management."

His work in constructive engineering was no less remarkable, for he designed the great steam hammer of the Midvale Steel Company, which was the largest successful hammer ever built in the United States, and the one steam hammer in all the world that could yield to the strain of a foul blow and by its elasticity recover its proper alignment.

In 1890 he left the Midvale Steel Company and became manager of The Manufacturing Investment Company, operating large paper mills in Maine, where he remained until his three year contract expired.

He then began, as consulting engineer, to introduce his principles of organization and management into various establishments about the country. During this period and in connection with this work he made many valuable improvements and inventions, a large number of which he patented.

In 1898 the Bethlehem Steel Company found that the output of their forge was much greater than the capacity of their machine shop to handle it. It was estimated that a new machine shop of sufficient capacity to keep up with the forge would cost one million dollars. At this juncture Mr. Taylor's success in producing increased shop efficiencies at other plants led the company to retain him to work at their problem.

Among the experiments made to increase the machine shop efficiency of the Bethlehem Steel Company were those on tool steel in conjunction with Mr. Maunsel White, leading to the discovery of the Taylor-White process of heat treatment, which increased the cutting capacity of tool steel 200 to 300 per cent. This process, and the tools treated by it, are now used in almost every machine shop in this country and abroad. They have revolutionized machine shop practice, and caused many radical changes in the machine tool industry. In the Bethlehem Steel Company's machine shop, where the discovery was made, the use of treated steel and the improved shop methods of Mr. Taylor resulted in such a remarkable increase in production that instead of an increase in the machine shop, an increase in the forge was necessary.

It was during his connection with the Bethlehem Steel Company that Mr. Taylor's ideas took concrete form on a large scale, and it is probable that during that time he first recognized the great possibilities of the broader application of the principles according to which he had been working, and realized the results that would be attained if these principles should become generally adopted throughout our industries. Having grasped the tremendous importance of this subject, Mr. Taylor decided, on leaving the Bethlehem Steel Company, to devote the remainder of his life to expounding these principles, which he now saw would create a new era in the industrial world.

He believed that he could do this to best advantage if he should make no charge for his work; and, having acquired a competency, he gave his services during the last fourteen years free to anybody who was sincerely desirous of carrying out his methods. He did more than this, for he not only invited everybody interested to his home, where he explained his methods to hundreds, and perhaps thousands, of people; but made extensive journeys at his own expense to lecture before interested bodies of people. It was on one of these trips that he caught the cold which resulted in his death.

Thus his work became known and appreciated not only all over this country, but in Europe and as far

as Japan. His books have been printed in almost all civilized countries, including Japan and China.

Although his qualities as an engineer command the admiration of all, his attributes as a man were quite as remarkable, and those who knew him best prized him even more as a man than as an engineer. His friends were quite as numerous among the workmen he came in contact with, as among his social equals; and those who had most to do with him freely testify to the benefit they received from his training and methods. Especially is this true with young men who have worked under him, and his success with them has been due to the fact that while an uncompromising and strenuous taskmaster, he recognized the value of time as an element in training, and was able to overlook the frequent personal issues which those who did not understand his methods insisted in raising at every turn. His remarkable ability to look beyond such issues and to see in them only incidents in the operation of broadening a man's view of work and duties, caused those who worked under him and understood his ideals to regard him as a friend who was always ready to give to his assistants full credit for their work.

He was Vice-President of The American Society of Mechanical Engineers in 1904 and 1905, and President in 1906, when he gave, as his presidential address, his exhaustive monograph, "On the Art of Cutting Metals," a treatise of 250 pages. Later he received the degree of Sc.D. from the University of Pennsylvania.

His written contributions were many; one of the earliest to come before the Society was his "Notes on Belting," presented in 1893. This paper contained the results of a long series of practical tests, and settled many contentions regarding the use and care of belts.

In 1895, he presented his paper on "A Piece-Rate System," in which he expounded the principles on which his system of management was subsequently based.

In 1903, he presented his celebrated paper on "Shop Management," in which he explained his methods in detail and the results to be derived from them.

In 1911, he published "The Principles of Scientific Management," which rounded out his theory of management.

He was joint author with Sanford E. Thompson of two works on concrete, "A Treatise on Concrete, Plain and Reinforced," and "Concrete Costs."

The funeral services for Dr. Taylor were held at the residence of his brother-in-law, Clarence M. Clark, Queen Lane Station, Philadelphia, when brief remarks of appreciation were made by James M. Dodge, Past-President, and Morris L. Cooke, Manager of the Society. The life and work of Dr. Taylor have received extended notice, both in the daily and technical press, and through the written comments of personal friends. Extracts from the remarks by Dr. Dodge and Mr. Cooke, and comments from other sources follow.

REMARKS BY JAMES M. DODGE

Dr. Frederick Winslow Taylor was a prophet, with honor in his own country and, at the same time, honored and respected in every civilized country of the globe. He was a remarkable student, a devoted husband, faithful friend, an inventor of the first rank, an engineer of resource, knowledge and keen perception, indefatigable in his work, unswerving in his devotion to truth, modest and considerate. With this remarkable combination of temperament and learning he became the bearer of a message that is destined to make him recognized the world over as the emancipator of the worker and the employer; delivering the worker from the oppressive burdens of the old order and granting him freedom to do his best for himself and his family; and his employer from the necessity of being only the taskmaster and granting him freedom and opportunity to be the friend and co-worker of those associated with him.

Through his scientific investigations of the relations between employer and employee he was able to formulate a system which made it possible for both parties to realize that their interests, instead of being in irreconcilable conflict, were identical and interdependent, and that all questions between them could be settled by kindness, forbearance and patient investigation without resort to mistrust, suspicion, or antagonism. *He was the bearer of the only flag of truce that was ever carried upon the battle field of industrial strife.* Ignorance and prejudice have fired upon this flag, but it was never lowered, and now that the hand that carried it must relinquish its noble office, thousands of others will sustain it in its exalted position. I predict that it will never be lowered, and that the employer and the employee will both prosper under it as they have never prospered before, and with increasing respect, regard and solicitude for each other's welfare.

Many others have prayed for an industrial social millennium, expecting it to come from spiritual grace through lapse of time, but Dr. Taylor not only saw the possibilities of the future but he did more; he told in detail exactly how this long-hoped-for condition might be actually accomplished at once. The seed he has sown is springing up in thousands of places; the message he gave us is making hundreds, yes, even thousands of converts; the work he so ably started is based upon eternal truth and will partake of the lasting characteristics of its foundation.

REMARKS BY M. L. COOKE

So much stress has been put upon the practical accomplishments of Frederick W. Taylor that the great reach and sweep of his *spirit* has, except for the few, been almost submerged. All this lifetime of patient, tireless investigation; all the acuteness of his highly scientific mind; all the aspirations of a sensitive nature were bent on the one end of making human life a better thing to live. To this object he made the freest possible sacrifice of his fortune, his time and his health.

The strength of the great movement which Mr. Taylor originated lay very largely in the devotion which we in the ranks felt for our leader. We rarely thought to call him a great man, it seemed like such a surface observation to any one who ever saw him at work. But we were always conscious of his incessant struggle, of the long weary years of battling to make men have faith in themselves.

He had a wonderful capacity for friendliness, a capacity that could stretch across seven seas, and last a lifetime and reach the lowest man in the ranks. He taught us our mutual dependence and then proceeded to carry nearly all the load. He tinged all our work with ideality. Hear his own words: "I can no longer afford to work for money"; "all

our inventions and changes are made to produce human happiness"; "in all your relations do to the other fellow what you would have him do to you." Just a year ago, Father Sertilanges, preaching in Paris, said: "The love of God is the Taylor system of our inner life (l'amour de Dieu est le systeme Taylor de notre vie interieure)." Mr. Taylor made us feel that there is nothing we cannot accomplish, and this without hurting our fellow men.

It was a part of the greatness of Mr. Taylor that he was not altogether concerned about the world's understanding of the greatness of his principles and motives. His loyal friends would do well to keep in mind his own words: "Patience, patience, and then more patience." His ideas forged ahead primarily because they were true and because they fitted in with the spirit of the time. But Taylor's "hanging on with his teeth," as he expressed it, and his willingness to stand alone when he was right, made them prevail.

Clean cut in his vision and keen in his judgments, fearless of criticism or misunderstanding, Frederick W. Taylor rang true in every act. He thought straight and spoke his mind with no uncertain sound and his speaking cleared the air of sophistries and evasions. No man who was ever honored by his friendship, sustained by his counsel, or upheld by his invincible spirit, can ever willingly set himself an easy task or be unwilling to tread the difficult way, so it be straight and clear.

FROM H. L. GANTT

Frederick Winslow Taylor's great contribution to the world's work was to substitute knowledge of human activities for opinion as a basis of action. His insistence that all industrial questions could be best answered by a scientific investigation was at first scoffed at by many of our industrial leaders, and it was nearly twenty years before he got much support. Now, however, at the end of thirty-five years, his persistence is bearing fruit so rapidly that the whole world is undergoing a revolution due to his ideas. His death cuts short the activities of a man who has had the welfare of his fellow men at heart, and who has devoted much of his life in trying to make clear the basis on which to establish industrial relations between employer and employee which shall be mutually satisfactory.

When he began his work all such relations were established by opinions. Today there are few industries in which fact has not supplanted many opinions. He had the feeling that waste was a crime, and that efficiency in work was a duty not only to ourselves and our employers, but to the community at large. His name will live as that of a man who could rise above individual cases and grasp general laws that would make for the happiness and prosperity of all.

If I were asked which piece of work more than any other illustrates his character as a man and an engineer, I would say the determination of the laws for cutting metals.

Finding himself balked at the outset of his career by a lack of knowledge on this subject, and realizing the great advantage that a knowledge of these laws would be to him and to the engineering profession in general, he determined to find out what they were. Suffice it to say that, although warned by his friends that he was attempting the impossible, and that for the first five years he scarcely made any real progress toward the desired end, he persisted in his work, to be rewarded after more than twenty years not only with the complete solution, but with the satisfaction of seeing the laws reduced to slide rules for their rapid application.

It was his persistent attempt to get uniformity in cutting tools that led, after nearly twenty years, to the discovery of the Taylor-White process of treating steel for cutting tools. This investigation involved at least fifty thousand experiments and cost probably over one hundred thousand dollars; the fact that he was able to carry to a successful conclusion such a gigantic undertaking in the face of the lukewarm support of his friends, and the determined opposition of all others, is a testimonial to his strength of character which needs no comments.

The solution of this problem will always be connected with his name as one of the greatest pieces of scientific investigation of the nineteenth century.

His discovery, in connection with Maunsel White, of the Taylor-White process, is a piece of scientific investigation almost as remarkable, and in its results quite as far reaching, for it is the basis of treating all the modern high-speed tool steels, which have so much reduced the cost of cutting metals. This discovery was the natural result of his habit of making a thorough investigation of every problem with which he was confronted, and fully justifies his practice of carrying investigations to their logical conclusions even though such conclusions seem contrary to all previous experience.

FROM THE ENGINEERING NEWS

The sudden death of Frederick W. Taylor removes from among us one of the acknowledged leaders of the engineering profession. Although his death occurs at a comparatively early age, Mr. Taylor had fully completed the great task of his life. His great achievement was the introduction to the engineering profession and to the industrial world of what has come to be known, for want of a better name, as scientific management.

It has been said that this was not originated by Mr. Taylor. Other men before him had followed, to a greater or less extent, the practice of setting tasks for workmen and giving them instructions as to the best methods of performing the task. This fact, however, detracts little from the great credit due Mr. Taylor as the originator of what was in effect a revolution in manufacturing industry. What others had attempted in an isolated and partial way, he did in a thorough manner and with a clear view of the underlying principles involved and the enormous scope and possibilities of the new system. By his personal force and ability, moreover, he brought the new system into extended use in a short time. Had it lacked such a strong and powerful advocate, its development would surely have been far slower and more uncertain.

It is unfortunately true that the system which he originated has been widely misunderstood and misapplied. Beside the school of able engineers who worked with Taylor and followed his methods and in many cases improved upon them, a host of imitators has sprung up everywhere who have nearly made the word efficiency a by-word of contempt. Misuse of the Taylor system to drive workmen beyond their strength has been one of the causes that has brought against it the antagonism of the labor unions. It is worth while to say at this time that nothing aroused the righteous wrath of Taylor more than the misuse of his system by employers as a tool to get more out of their hands. He always believed and always urged that an essential feature to the success of his system was that the profit representing the increased efficiency resulting from its application should be equitably divided between the workers and the employer.

That many faults and imperfections have developed in the operation of Taylor's system and similar systems which imitators have brought forth, will be freely acknowledged by impartial observers. It remains true nevertheless that the system of scientific management which he to a large extent created is probably the greatest labor-saving instrument that has been developed in modern times.

THE SEE LIBRARY

Through the kindness of Mr. John Philp, Vice-President of the Glasgow Iron Works, New York, the Society has been the recipient of the collection of technical books forming the library of Horace See, who died December 14, 1909. Mr. See had given the library to Mr. Philp, but through the thoughtfulness of Mr. Philp the Society is now the owner of the books.

Mr. See was President of the Society in 1888, and was associated with the shipbuilding firm of William Cramp and Sons as designer and superintending engineer. It was under his leadership that the contracts for the first vessels of the "New Navy" of the United States were taken by his firm. He was also designing engineer for the transatlantic ships of the American Line.

The See Library is rich in the early works on naval architecture and the steam engine, especially the marine engine. It contains complete sets of several engineering periodicals and a large collection of pamphlets of a technical nature.

The collection will bear an appropriate special bookplate and will considerably strengthen the Society's contribution to the Library of the United Engineering Societies, where the collection will be catalogued and arranged.

UNITED ENGINEERING SOCIETY

REPORT OF TREASURER

TO THE BOARD OF TRUSTEES,
UNITED ENGINEERING SOCIETY.

I respectfully submit the following report of your Treasurer for the year ending December 31, 1914.

FINANCES

The Balance Sheet submitted herewith shows the physical property of the United Engineering Society, over and above the value of the building and the equity in the land, to consist of building equipment of a value of $33,171.36, and library books $1,698.75.

There was added to Furniture and Fixtures Account during the year 1914 an amount representing an expenditure of $671.62, the principal items of which are: Typewriter for Library $100, two reflectors $50, cabinet $60, mail box $85, sign-boards $47.38, hall runner $37, and shades purchased during the year, $207. In accordance with a resolution of the Board of Trustees, the total amount of furniture and fixtures at December 31, 1914, viz., $6,467.08, has been written off.

The operations for the year 1914 resulted in a surplus of $13,383.60, against which amount there has been charged by direction of the Board of Trustees, the Furniture and Fixtures Account amounting to $6,467.08, also a transfer to Depreciation and Renewal Account of $20,000, leaving a charge to Surplus Account of $13,083.48, thus reducing the surplus of $43,437.96 of January 1, 1914 to $32,374.48.

The principal of the mortgage on the land held by Andrew Carnegie, Esq., amounting originally to $540,000, has been reduced by payments from the Land and Building Fund of the Founder Societies to $59,000. Payment of $29,000 was made during the year by the American Institute of Mining Engineers.

The present balances due from the Founder Societies are as follows: American Institute of Electrical Engineers, $54,000, and American Institute of Mining Engineers $5,000. The American Society of Mechanical Engineers has paid the full amount of its land indebtedness.

The gross operating expenses for the year 1914 were $39,581.64, as compared with $39,156.83 for the preceding year, showing an increase of $424.81 for the year.

In accordance with a resolution of the Board at a meeting held on February 26, 1914, an appropriation of $10,000 was made out of the surplus for the year 1913, and of this amount $9,900 was invested in the purchase of $10,000 Interborough Rapid Transit First Refunding 5% Bonds repayable 1966 at 99 as an addition to the Depreciation and Renewal Fund as provided for in the Founders Agreement, bringing the amount invested on account of this Fund to $39,863.75.

Pursuant to a resolution of the Board of Trustees at a meeting held November 19, 1914, all interest earned by the investments on account of the Depreciation and Renewal Fund is to be added to this Fund. For the year 1914 this interest amounted to $1,441.39, bringing the fund to $41,441.39. A further resolution at this meeting directed that a transfer from this Fund of $10,000 be made to "General Reserve Fund" to be available to take care of unforeseen fluctuations of income or outlay. The "Depreciation and Renewal Fund" to provide against gradual disappearance of this Society's assets now amounts to $31,441.39.

A resolution passed by the Board November 19, 1914, provided that a sum not exceeding $20,000 be transferred to Depreciation and Renewal Fund. On the advice of the Finance Committee acting under this resolution the entire sum of $20,000 was set aside.

The following summary shows the reserve accounts and the investments therefor:

Depreciation and Renewal Fund	$30,000.00
Add: Interest on invested funds, year 1914	1,441.39
Transfer for the year 1914	20,000.00
	$51,441.39
General Reserve Fund	10,000.00
	$61,441.39

The investments made on account of these funds are as follows:

INVESTMENT

$10,000	Interborough Rapid Transit Bonds 1966.
5,000	N. Y. City 4½% Bonds 1917.
5,000	N. Y. City 4¼% Bonds 1930-1960.
5,000	N. Y. City 4¼% Bonds 1962.
5,000	Baltimore & Ohio 4% Bonds 1948.
5,000	Delaware & Hudson 4% Bonds 1943.
6,000	Southern Rwy. Co. 4% Bonds 1956.
	PURCHASES OF JAN. 11, 1915.
10,000	Chicago & Northwestern 5% Bonds 1987.
8,000	Northern Pacific 4½% Bonds 2047.
$59,000	

At the November meeting the Board of Trustees appointed the Astor Trust Company of New York City the custodian and attorney of the United Engineering Society

for the purpose of holding the securities and collecting the interest and dividends thereof, accordingly, the securities above listed have been deposited with the Astor Trust Company.

The assessments paid for the year 1914 by the Founder Societies, each apportioned one entire floor, were $3,375, representing as last year a total expenditure by each Society, including interest on its full principal of mortgage on land of $10,575, reduced in each case to the extent the Society may have paid off part or all of its mortgage share. The associate societies are assessed approximately $10,000 for equivalent privileges, which shows that the Founder Societies still meet a little more than their proportion of the carrying charges for equivalent office space occupancy in the building. In accordance with a resolution passed by the Board of Trustees November 19, 1914, each Founder Society will be assessed monthly at the rate of $12,000 per annum beginning January 1, 1915, and each society will be credited with 4 per cent upon the sum of its payments on account of its land mortgage, and a further credit for space released by any Founder Society.

BUILDING

Equipment. The Real Estate Equipment Account during the year 1914 has been increased to the extent of $5,814, expended mainly for labor and material for additions and alterations on the 6th floor of the United Engineering Building and architects' fees in connection therewith.

Office Occupancy. There was on January 1, 1914 no unoccupied floor space (devoted to office space) in the building. There are now seventeen associate societies occupying office space in the building.

Meetings or Lectures. The record of the number of times the rooms were used during 1914 for meetings or lectures (not for office occupancy) is:

MEETING ROOM.

	Number of times occupied.		
	1913.	1914.	Change.
Auditorium, 3d and 4th floors	69	76	7 more.
No. 1 Assembly Room, 5th floor	56	58	2 more.
No. 2 Assembly Room, 5th floor	129	94	35 less.
No. 3 Assembly Room, 5th floor	101	46	55 less.
No. 5 Lecture Room, 6th floor	10	0	10 less.
No. 8 Lecture Room, 6th floor	20	0	20 less.
Assembly Room 1201, 12th floor	18	53	35 more.
Committee Room (off foyer), 1st floor	10	18	8 more.
Total	413	345	68 less.

During the year 1914 the facilities of the building were used by 54 Societies holding a total of 251 meetings, with an attendance of 50,778 as compared with 56 Societies holding 309 meetings with an attendance of 63,348 during 1913.

LIBRARY

During the year 1914 there was added to the Library of the three Founder Societies and United Engineering Societies 3,616 volumes and pamphlets, of which 1,142 volumes and pamphlets were purchased at a cost of $3,153.20. The total number of books and pamphlets at the end of the year was 57,861.

The attendance during the year was 13,512 as compared with 11,091 during 1913, an increase of 2,421.

One hundred and ninety-eight Searches have been made during the year. Correspondence has come from all over the world, and the questions are of great variety. Several hundred photographic reproductions have been made and sent out. More than twelve hundred reference questions have been answered at the desk.

The Library receives more than 800 periodicals which are available through indexes for research purposes.

Respectfully submitted,

(*Signed*) JOS. STRUTHERS, *Treas.*

UNITED ENGINEERING SOCIETY

BALANCE SHEET, JANUARY 1, 1915.

ASSETS

Real Estate—Land		$540,000.00
Real Estate—Building		1,050,000.00
Real Estate—Equipment		33,171.16
Southern Railway Co. $6,000 4% Gold Bonds 1956		4,755.00
New York City $5,000 4½% Reg. Bonds 1917		5,231.25
Baltimore & Ohio $5,000 4% Cpn. Bonds 1948		5,037.50
New York City $5,000 4¼% Reg. Bonds 1930-1960		5,062.50
New York City $5,000 4¼% Cpn. Bonds 1962		4,943.75
Delaware & Hudson Co. $5,000 4% Cpn. Bonds 1943		4,933.75
Interboro R. T. Co. $10,000 5% Cpn. Bonds 1966		9,900.00
Library Books, U. E. S.		1,688.75
Library Adjustment Account		95.64
Accounts Receivable		4,936.66
Unexpired Insurance		3,333.10
Cash:		
Working Balance	$2,881.14	
For Depreciation and Renewal Fund	20,000.00	
Ways and Means Committee	1,165.08	
		24,046.22
Petty Cash		500.00
		$1,697,635.28

LIABILITIES

Balance of Land A. I. E. E.	$54,000.00	
Balance of Land A. I. M. E.	5,000.00	
		$59,000.00
A. I. E. E. Equity in Building		350,000.00
A. S. M. E. Equity in Building		350,000.00
A. I. M. E. Equity in Building		350,000.00
A. I. E. E. Equity in Real Estate Equipment		3,346.61
A. S. M. E. Equity in Real Estate Equipment		3,346.62
A. I. M. E. Equity in Real Estate Equipment		3,346.62
A. I. E. E. Payments to date in liquidation of Mortgage on Land		126,000.00
A. S. M. E. Payments to date on liquidation of Mortgage on Land		180,000.00
A. I. M. E. Payments to date in liquidation of Mortgage on Land		175,000.00
Depreciation and Renewal Fund		51,441.39
General Reserve Fund		10,000.00
Ways and Means Committee		1,165.08
Library Adjustment Accounts		68.95
Accounts payable		2,545.83
Surplus Account		32,374.48
		$1,697,635.28

UNITED ENGINEERING SOCIETY

STATEMENT OF RECEIPTS AND DISBURSEMENTS, YEAR ENDING DECEMBER 31, 1914

CASH RECEIPTS

Balance on hand, January 1, 1914		$27,611.28
Account of Interest on Mortgage	$3,365.73	
Assessment—Founder Societies	10,125.00	
Assessment—Associate Societies, Offices, Meetings, etc.	49,993.66	
Library Account	7,148.86	
Interest on Bonds and Deposits	2,238.27	
A. I. M. E. in reduction of Mortgage	29,000.00	
		101,871.52
		$129,482.80

DISBURSEMENTS

Account of Interest on Mortgage	$2,685.73	
Account of Real Estate Equipment	5,814.00	
Operating Expenses—Cash Expenditure	39,280.93	
Furniture and Fixtures	653.62	
Library Account	7,992.64	
Bonds Purchased — Depreciation and Renewal Fund	9,900.00	

Accrued Interest on Bonds Purchased	98.61	
Accounts Payable	1,208.09	
A. I. M. E.—Office Space Released	3,912.00	
Insurance	3,423.66	
Library Adjustment	70.55	
Payments in reduction of Mortgage	29,000.00	
Library administration expenses	2,396.75	
		105,436.58
Balance on hand, January 1, 1915		24,046.22
		$129,482.80

UNITED ENGINEERING SOCIETY

OPERATING INCOME AND EXPENSES, YEAR ENDED DECEMBER 31, 1914

INCOME

Assessments:		
Founder Societies		$10,125.00
Associate Societies	$32,004.81	
Less: Refund for Office Space released	3,912.00	
		28,092.81
Miscellaneous (Offices and Meetings)		10,916.16
Telephone Returns		4,789.96
Miscellaneous Charges to Societies, etc		2,328.46
United Engineering Society Library Returns		200.25
Interest on Bank Balances		698.27
Library Inventory Adjustment (Donations)		462.47
		$57,613.38
Balance charged to Surplus Account		13,083.48
		$70,696.86

EXPENSES

Operating Expenses, Gross	$39,581.64
Insurance	1,051.39
Library Maintenance Expense	1,200.00
Library Administration Expense	2,396.75
Furniture and Fixtures written off	6,467.08
Depreciation and Renewal Fund	20,000.00
	$70,696.86

ANNUAL DINNER AT BOSTON

The Sixth Annual Engineers' Dinner was held at the Boston City Club, February 15, 1915, under the auspices of the Boston Society of Civil Engineers, The American Society of Mechanical Engineers and The American Institute of Electrical Engineers; the arrangements this year being handled by the Boston Society of Civil Engineers. There were 271 at the dinner and it was a very enthusiastic gathering. The toastmaster was James W. Rollins, president of Holbrook, Cabot & Rollins, Engineers and Contractors. An account of the meeting follows:

The first speaker of the evening was Harrison P. Eddy of the firm Metcalf & Eddy, Consulting Engineers, who is President of the Boston Society of Civil Engineers.

Mr. Eddy heartily welcomed the engineers present and spoke of the great benefit to be derived from these annual dinners.

The next speaker was Charles W. Baker, Editor in Chief of the Engineering News who in speaking of the opportunities for public service by the engineer referred to the work some of the engineering societies are doing in the way of following up the bills which are being presented to the State Legislatures. The committees who do this work have to make a report, the matter is then discussed and if possible a change in the bill is agitated if necessary. As one looks out on the world today, he sees two great forces struggling with each other, conservatism and radicalism. Thirty years ago conservatism was in the lead, but since that time a most amazing change has taken place, and radicalism today is far in the lead but the great body of engineers should try to keep on the middle ground. The Child Labor Laws which are being agitated at the present day are causing quite an uproar all over the country. Intelligent men and women are on the platform in all the large centers speaking for more and more laws. The meaning of much of this is that every child should be prevented by law from performing any useful work before it reaches the age of 16 years. If this extreme ideal were carried into effect, we would produce a group of perfectly useless men and women. The enforced idleness which would take place would cause a great deal more harm than all the child labor now being performed. The boys and girls who were born and brought up on the New England hill sides and farms know what hard work means and in later years they know the joy of doing things.

Mr. Baker then touched upon the subject of government ownership and stated that probably within the next 25 years we should see the greater portion of the present day public utilities under government ownership. He said that he knew that some of the present day government methods are bad and that something must be done to correct them, and that it was up to engineers and the other men to give more time toward the correcting of the defects and take more interest in the affairs of government, city, state and national. Reforms should be put through so that these men can attain prominent positions and high rewards, and not lose their jobs every time there is a change of administration.

The next speaker was Chas. H. Eglee, manager dam and power dept. Aberthaw Construction Co. He said that the men today are losing their old ideas of standards and establishing new ones, which are better ones. He called attention to the various classes of engineers we have at the present day, the publicity engineer, mechanical engineer, hydraulic engineer, electrical engineer, mining engineer and steel engineer. Everything is trying to expand along new lines. The trade unions are trying to work as little as possible for as high a pay as possible in order that the working man may have an opportunity to improve himself; while on the other hand, the efficiency engineer with his stop watch is drifting in the direction of regarding a man as a machine. There we have the trade union on the one hand and the efficiency engineer on the other. The engineer, however, who is developing the finer qualities of manhood, giving each man an opportunity to expand as his individual qualifications make it possible, is the one who produces the productive man.

The next speaker was Capt. Robert W. Bartlett, the man who was the skipper of the ship Roosevelt when Peary discovered the North Pole and who later went with Steffanson up to the Arctic. He gave a number of personal experiences up in the North.

The Governor of the Commonwealth of Massachusetts, Hon. David I. Walsh, was the next speaker. He called attention to the great amount of good work the engineer could do by interesting himself in the affairs of the city and state, and spoke about the difficulty he had had in trying to induce engineering men to enter the public service. He hoped that the day would come when prominent engineers now in private practice would devote some of their time to the affairs of government.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before May 10, 1915.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ALBERGER, ALVAN H., Pres., Alberger Gas Eng. Co., Buffalo, N. Y.

ALLEN, ETHAN E., Engr., Abaca Products Co., Manila, P. I.

ALVERSON, H. B., Supt. and Engr., The Cataract Pwr. & Conduit Co., Buffalo, N. Y.

ARFF, JOHN G. H., Supt. of Pwr., Christian Moerlein Brewing Co., Cincinnati, Ohio.

BAKER, ROBERT E., Secy. and Treas., Arthur G. McKee & Co., Cleveland, Ohio

BARLOW, FREDERIC C., with Phoenix Mfg. Co., Eau Claire, Wis.

BARR, CLARENCE D., Ch. Engr., American Cast Iron Pipe Co., Birmingham, Ala.

BEALE, HORACE A., JR., Pres., Parkesburg Iron Co., Parkesburg, Pa.

BEEBE, LAWRENCE L., Asst. Mech. Engr., Off. Pub. Rds., U. S. Dept. of Agri., Washington, D. C.

BELL, EDGAR D., Genl. Supt., St. Louis Elec. Terminal Ry. Co., St. Louis, Mo.

BERGGREN, AXEL E., Instr. in Steam and Gas Engrg., Univ. of Wisconsin, Madison, Wis.

BEVER, JOHN J., Mgr. Fdy. Dept., The Otis Steel Co., Cleveland, Ohio.

BOOTHMAN, DALE M., Ch. Draftsman, Shredded Wheat Co., Niagara Falls, N. Y.

CAREY, THOMAS H., Supt. Engrg. and Insp. Dept., Globe Indemnity Co., New York.

CARNEY, JOSEPH F., Mech. Supt., Greeley Square Hotel Co., New York.

CARSON, CLARENCE, Cons. Engr., H. W. Johns-Manville Co., New York.

CHESTER, THOMAS, Ch. Engr., American Blower Co., Detroit, Mich.

COONEY, JAMES L., Supt., Cayuga Lake Plant, International Salt Co., Myers, N. Y.

CORBETT, CHARLES F., Supt., City of Edmonton Filtration Plant, Alberta, Canada.

DAILEY, FRED A., Pres. and Treas., Union Mch. Co., Contracting Engrs., St. Paul, Minn.

DECKER, GEORGE A., Wks. Engr., The Warner & Swasey Co., Cleveland, Ohio.

DEVINE, JOSEPH P., 1372 Clinton St., Buffalo, N. Y.

DEWOLF, PAUL C., Asst. Treas., Brown & Sharpe Mfg. Co., Providence, R. I.

DODGE, PARKER VAN P., Patent Solicitor and Mem. of Firm, Dodge & Sons, Washington, D. C.

DURWARD, ERIC S., Asst. Supt., California Oilfields, Ltd., San Francisco, Cal.

EYRE, THOMAS T., Asst. Prof. of Mech. Engrg., Purdue Univ., Lafayette, Ind.

FERGUSSON, DAVID, Mech. Engr., Pierce-Arrow Motor Car Co., Buffalo, N. Y.

FLANDERS, WARREN B., Supt. of Pwr., Havana Elec. Rwy. Lt. & Pwr. Co., Havana, Cuba.

FREEMAN, FREDERICK S., Supt. Pwr. Operation, Boston Elevated Ry. Co., Boston, Mass.

FREEMAN, HERBERT A., Designing Engr., G. M. Davis Co., Chicago, Ill.

GARDNER, ARCHIBALD, Asst. to Pres., Ambursen Co., New York

GOOD, PAUL E., Mech. Engr., Southwark Fdy. & Mch. Co., Philadelphia, Pa.

GOODLING, H. P., with A. B. Farquhar Co. Ltd., York Pa.

HAGGERTY, EDWARD D., Supervising Engr., Employers Mutual Ins. Co., New York.

HAMILTON, ROBERT, Mgr., Robt. Hamilton & Co., Vancouver, B. C., Canada.

HELMSTAEDTER, WILLIAM E., Mech. Engr., The Celluloid Co., Newark, N. J.

HERMAN, SAMUEL J., Vice Pres. and Genl. Mgr., Diamond Pwr. Specialty Co., Detroit, Mich.

HOWARD, LESLIE E., Mech. Engr. and Metallurgist, Simonds Mfg. Co., Lockport, N. Y.

HOWE, CHARLES S., Pres., Case School of Applied Science, Cleveland, Ohio.

JAMES, WILLIAM A., Ch. Engr., Lackawanna Steel Co., Buffalo, N. Y.

INOKUTY, ARIYA, Prof. of Mech. Engrg., College of Engrg., Imperial Univ. of Tokyo, Japan.

KING, WALTER A., Supt., Parker Bros. Gun Mfg. Co., Meriden, Conn.

LACOMBE, CHARLES F., Cons. Engr., New York

LAMBUTH, LEONARD L., Asst. Supt., The United States Portland Cement Co., Concrete, Colo.

LANE, GEORGE H., Secy. and Treas., C. J. Moberg, Inc., Mt. Vernon, N. Y.

LEHN, HENRY C., with International Steam Pump Co., Buffalo, N. Y.

MACDONALD, KARL, Ch. Mech. Engr., Clarksburg Water Wks. and Sewerage Board, Clarksburg, W. Va.

MACKIE, EDWIN M., Asst. Engr., Pneumelectric Mch. Co., Syracuse, N. Y.

MELENDY, JESSE G., Supt., Buffalo Wks., General Chemical Co., Buffalo, N. Y.

MERRILL, EDWIN R., Plant Engr., The Niles Tool Wks. Co., Hamilton, Ohio

MURPHY, JOSEPH E., Mgr. Mchy. Dept., Eccles & Smith Co., Inc., Los Angeles, Cal.

NASH, JAMES E., Supt., Worcester Salt Co., Silver Springs, N. Y.

NEAL, JOHN R. H., with Robert Neal & Co., Buffalo, N. Y.

NEWELL, FREDERICK H., Cons. Engr., U. S. Reclamation Service, Washington, D. C.

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THE CLINKERING OF COAL

BY LIONEL S. MARKS, CAMBRIDGE, MASS.

Member of the Society

The Friday morning Session of the Annual Meeting, December 4, 1914, was devoted to a number of papers upon miscellaneous subjects. Five of these appeared in abstract in the March Issue of The Journal, pages 159 to 179. The remaining paper of this group, The Clinkering of Coal by Lionel S. Marks, is here presented in abstract form together with abstracts of the discussion which followed.

THERE is a growing feeling that the matter of clinkering ought to be taken care of when making contracts for coal and that specifications ought to include the melting temperature of the ash as indicating the clinkering characteristics of the coal.

The useful items in modern specifications for coal are the heat of combustion of the coal and its water and ash content. The latter permit calculation of the cost of handling inert matter when firing the coal and when disposing of the ashpit refuse. The volatile content of coal has an indirect interest in indicating its general nature but does not give any definite information about burning qualities. The important things about which specifications give no information are (*a*) as to the burning qualities of the coal (free burning or dead, caking or non-caking, etc.) and (*b*) the clinkering characteristics of the ash.

Before the subject of clinkering can be put upon a satisfactory basis, two kinds of measurement are necessary; (*a*) the determination of the extent to which the clinkering of a given coal is objectionable in actual use, and (*b*) the determination by a laboratory test of some characteristic of the ash which indicates the objectionableness of the clinkering. Some clinkers give very little trouble and are not particularly objectionable even when present in large amount. This is especially true of such clinkers as are non-adherent, easily broken up and easily removed. On the other hand, a small quantity of clinker which forms a pasty mass with the surrounding coal, or which runs on to the grate and freezes there as a strongly adherent but thin sheet, gives a very great deal of trouble and diminishes both the capacity and efficiency of a boiler considerably.

It is probable that the only reliable basis at present for determining the "objectionableness" of the clinker, is the judgment of fireroom observers. The writer has attempted to get a quantitative measurement by sifting the ashpit refuse into a number of selected sizes. In tests made with a Murphy stoker equipped with the usual clinker-breaker, the coals which gave most trouble were found to have the lowest percentage of smallest size clinker (less than 1 in.), and the highest percentage of the largest size clinker (greater than 2 in.). The differences between the percentages of the different sizes for good and poor coals is but small, so that the method cannot be relied on, but these observations have been used to confirm the judgment of the fire-room observers.

The only kind of laboratory test on coal ash which would seem to be of any real value is one in which the ash is subjected to such temperature as will cause it to melt either wholly or in part. A number of attempts have been made to determine the melting temperature of an ash from its chemical analysis, but none of these attempts has been satisfactory, nor does it seem probable that this method will ever be available in view of the great complexity of the chemical constitution of coal ash.

That valuable indications may be obtained from a knowledge of the iron and sulphur content of the coal or of its ash, is suggested by some recent tests of Palmenburg[1] which, as pointed out by Bergwyn,[2] appear to show the following results:

a An ash containing less than 10 per cent of iron oxide (Fe_2O_3) does not fuse at a temperature below 2550 deg. fahr.; an ash containing more than 20 per cent does not fuse at a temperature above 2550 deg. fahr.; for an ash containing between 10 and 20 per cent the fusing temperature varies widely.

b A coal containing less than 1 per cent of sulphur does not fuse at a temperature below 2550 deg. fahr.; a coal containing more than 2 per cent does not fuse at a temperature above 2550 deg. fahr.; for a coal containtaining between 1 and 2 per cent the fusing temperature varies widely.

c A coal containing less than 3 per cent of iron oxide plus sulphur does not fuse below 2550 deg. fahr.; and a coal containing more than 3 per cent does not fuse above 2550 deg. fahr.

The determination of melting temperatures of coal ash is attended with many difficulties, the most important of which is in the definition of the melting temperature. When a coal ash is heated slowly, that one of its constituents which is the most fusible will be the first to melt. Its effect upon the rest of the ash will depend upon three factors: (*a*) the amount of that constituent; (*b*) its viscosity when melted; and (*c*) its chemical reaction on the remaining constituents. If there is much of this constituent the ash will become fluid to an extent which depends upon its viscosity. If the molten part is small in amount but very fluid, it may separate from the rest. With certain constituents, a eutectic may be formed whose melting temperature has but little relation to the melting temperatures of the constituents.

The best method of determining the extent to which melting has gone on at any given temperature, is probably that which has been used so successfully by the Geophysical Laboratory at Washington. In this method a small mass of the ash is kept at the desired temperature for a time sufficient to insure that the melting corresponding to that temperature is complete. The melt is then quenched and a thin

Abstract of paper and discussion presented at the Annual Meeting, December, 1914. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

[1] Journal of Industrial and Engineering Chemistry, April, 1914.

[2] Journal of Industrial and Engineering Chemistry, August, 1914.

section of it is examined under the microscope. This method, however, may not be the most valuable for the determination of the clinkering characteristics of an ash.

There is another factor of great importance in connection with the behavior of molten coal ash, namely, its viscosity, which a satisfactory laboratory test for clinkering should indicate as well as melting temperature. The only method which has been used to any extent for this purpose, is really an imperfect method of determining the temperature at which the material has a standard viscosity. This is accomplished by heating the material in the form of a Seger cone of standard dimensions, at a standard rate, until it has bent to some standardized final form. The cone has usually been set up vertically. The rate of rise of temperature is usually taken as 2 deg. cent. (or 4 deg. fahr.) per minute, and the melting temperature is taken as that at which the tip of the cone touches the base. This method, it will be observed, does not really give a standard viscosity unless the time from the beginning of bending is the same in all cases. It should be noted also that the temperature of the cone increases as the bending goes on.

In tests by the writer with a standard rate of heating of 2 deg. cent. per minute, the time taken for the cone to bend to its final position from the beginning of bending, has varied

FIG. 1 APPEARANCE, AFTER FUSION, OF A CONE CONTAINING A VERY FLUID CONSTITUENT

from 10 to 80 minutes; the final viscosities in these two cases are obviously very different. It should be noted that even if this method gave standard viscosities, it would not necessarily give information of any value on clinkering. If it were true that all clinkers became troublesome when they reached a certain lower limit of viscosity, and if that particular viscosity were chosen as the standard, one might expect a close relation between laboratory and fireroom results. It has not, however, been shown that there is a lower limit of viscosity of the ash which cannot be exceeded without trouble from clinker, and moreover, in ashes whose most fusible constituents are very fluid the Seger cone method fails as indicated above.

Notwithstanding these inherent defects, the Seger cone method appears to merit further investigation, but an important modification in its use seems to be advisable. In the standard method the cones are placed vertically. This gives satisfactory results with the original Seger cones with many fire clays, but is often unsatisfactory with more complex mixtures. If the more fusible constituents are very fluid they run down to the base of the cone and may leave the apex apparently unchanged in a vertical or slightly inclined position (Fig. 1) until it disappears; that is, the cone never assumes the standard final shape. Furthermore, even cones which behave in the normal way may be difficult to observe since their direction of bending is not readily predictable or controllable without preliminary inclining or nicking. Mr. J. P. Sparrow of the New York Edison Company has suggested placing the cones horizontally with the apex projecting over the side of the support. This method has been adopted by the writer as being more sensitive than the usual method and as giving indications which can be duplicated more accurately and are therefore more reliable. The temperatures noted in this method of testing are at the beginning of bending and when the apex of the cone points vertically downward.

The Seger cone method with the cone placed either vertically or horizontally, is used by a number of observers, but with an enormous diversity of the results obtained in different laboratories. This diversity results from differences in methods of testing, from differences in the definition of melting temperature, and also from the difficulties surrounding accurate pyrometric work. The writer has endeavored to ascertain the influence of the various factors which may affect the apparent melting temperature. The more important factors are (*a*) nature of the surrounding atmosphere; (*b*) size of the cone; (*c*) position of the cone; (*d*) nature of the binder; (*e*) rate of heating; (*f*) location of the cone in the furnace; and (*g*) method of support of the cone.

TABLE 1 INFLUENCE OF POSITION OF CONE ON MELTING TEMPERATURE

Date	Melting Temperature Deg. Cent.		Difference Deg. Cent.
	Vertical Cone	Horizontal Cone	
Feb. 3	1430	1395	35
4	1410	1400	10
5	1410	1400	10
6	1390	1380	10
10	1380	1370	10
13	1440	1395	45
Mar. 3	1440	1420	20
5	1365	1370	5
11	1400	1380	20
13	1445	1395	50
24	1470	1450	20
Seger No. 12 (full size)	1350	1300	50
Seger No. 16 (small size)	1450	1420	30

a Nature of Surrounding Atmosphere. Many of the writer's earlier tests were made with a Hoskins carbon resistance furnace in which the atmosphere is necessarily reducing and in which CO is always present. Preliminary tests on Seger cones gave results which agreed very closely with the readings of a Fery optical pyrometer. The melting temperature of the standard Seger cones was found to be unaffected by the nature of the surrounding atmosphere. With ash cones, however, it was found that the fusing temperatures, as observed in the Hoskins furnace, were in all cases much higher than those obtained in a Meker furnace in which an oxidizing atmosphere was maintained. The temperature in the Meker furnace was read by a Le Chatelier pyrometer which showed close agreement both with the Fery pyrometer and with the indications of Seger cones. The cones were all vertical, and the temperature differences ranged from 120 deg. to 255 deg. cent. (260 deg. to 459 deg. fahr.). It should be noted also that even the order of fusibility was changed in some cases when the at-

mosphere is changed, and that the lower the fusing temperature in an oxidizing atmosphere the greater is the increase in fusing temperature when changing to a reducing atmosphere. It is of prime importance that the cone should be surrounded by an oxidizing atmosphere.

b *Size of Cone.* The size of cone has an influence which is different for different materials. With Seger cones the difference is negligible. For example, a No. 16 Seger cone (17 mm base, 70 mm high) placed horizontally, has a melting temperature (initial and final bending) of 1355 to 1410 deg. cent.; when molded into the standard size of Seger cones of higher fusing temperature (8 mm base, 30 mm high), the result is 1355 to 1420 deg. cent. The size of cone adopted in the writer's tests was 11 mm base and 52 mm high. The ash of March 24 tested horizontally in a cone of this size gave melting temperature 1425-1450 deg. cent.; in a 13 mm base, 57 mm high cone, the temperature was 1400-1430 deg. cent. As is to be expected, the larger cones show a lower melting temperature but the difference is not great.

c *Position of Cone.* The melting temperature (complete bending) of a horizontal cone is always less than for a vertical cone, as shown by Table 1. The difference varies considerably and is less with the more fluid melts. The cones of March 5 or February 10 showed a particularly fluid melt.

d *Nature of Binder.* The ash is usually mixed with a 10 per cent solution of dextrin before molding into cones. It was found, however, that water alone was satisfactory if the cones are not dried much before putting in the furnace. The effect of adding dextrin is generally negligible, but sometimes it increases the apparent fusing temperature (complete bending) by as much as 10 deg. cent.

e *The Rate of Heating Cones* has a marked effect on the apparent fusing temperature. Any increase in the rate results in increased lag of the pyrometer (Le Chatelier type with porcelain tube), and causes an apparent decrease in the melting temperature. Tests on the ash for February 4 and February 6 showed melting temperatures (complete bending) which were 40 deg. and 35 deg. cent. respectively lower, with 6 deg. cent. increase per minute, than with 2 deg. cent. increase per minute.

f *The Location of the Cone* in the furnace is important; it should be as close to the pyrometric element as possible. The temperature at the front of a No. 29 Meker furnace was found to be about 20 deg. cent. lower than that in the middle of the muffle. An additional door plate reduced this difference.

g *The Cone must be Supported* on material which is unaffected by the highest temperature reached and which does not react chemically on the ash cones. Plates of fused quartz have proved very satisfactory in the writer's tests. They have to be supported in such a way as to permit circulation of the gases below them so that they shall have the same temperature as the rest of the muffle.

Another point of importance is the complete incineration of the ash before it is made into a cone. An appreciable amount of carbon remaining unburned tends to increase the apparent fusing temperature.

The arrangement of apparatus finally used in the writer's tests is shown in Fig. 2. Holes were made in the back of the furnace for the insertion of the pyrometer, and in front for observation and for the insertion of a quartz tube through which a stream of air was introduced into the muffle to ensure an oxidizing atmosphere. The furnace was heated rapidly to within about 200 deg. cent. of the expected fusing temperature and the rate was then reduced to 2 deg. cent. per min., and was kept there. The observation hole was plugged up except when in use. Observations were made through very dark blue glass at 2½ min. intervals. The horizontal cones were supported only so far as was necessary for balance.

In order to find out whether fusing temperatures as determined by the method outlined above, have any relation to the amount of clinker trouble experienced in burning the coal, a series of tests was carried out on a boiler equipped with a Murphy Stoker at the L Street plant of the Edison Electric Illuminating Company of Boston. Fourteen tests were made, each of 24 hours duration, with 10 different coals; 5 of the tests were made with one coal, and 1 test with each

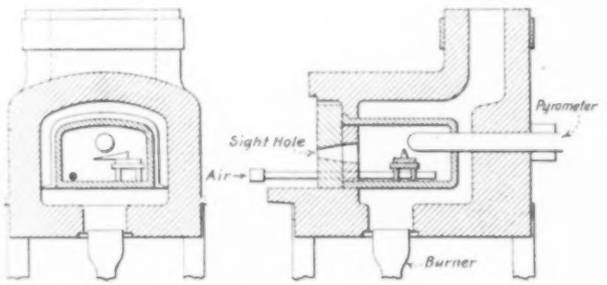


Fig. 2 Arrangement of Apparatus used in Tests

of the 9 remaining coals. Table 2 gives the results of tests of the ash and a statement of the extent of the clinkering for each of these tests.

It will be seen that there is a general relation between the two but that it is not definite enough to be of much practical use. The coals giving the three lowest fusing temperatures (February 10, March 5, April 8) are also those giving the maximum clinker trouble. Those ashes with a final fusing temperature of 1400 deg. cent. (2552 deg. fahr.) or higher, gave little trouble, but the ash of February 6, which melted at 1380 deg. cent. (2516 deg. fahr.) gave little trouble, while those of February 13 and March 13 which melted at 1395 deg. cent. (2543 deg. fahr.) gave much trouble. The most troublesome clinkers (February 10, March 5 and April 8) had final melting temperatures of 1370 to 1375 deg. cent. (2498 to 2507 deg. fahr.) which is practically the same as the temperature for the good coal of February 6. It would appear then, that the final melting temperature cannot be taken as a criterion in the range from 1380 to 1400 deg. cent. (2516 to 2552 deg. fahr.) and the inference is that the uncertain region extends over a still wider temperature range. It is probably true that final fusing temperatures below 1350 deg. cent. (2462 deg. fahr.) show a coal which would give clinker trouble under the conditions of the L Street Station, and that temperatures above 1420

deg. cent. (2588 deg. fahr.) indicate a coal comparatively free from such trouble, but further investigation would be necessary to establish that fact. The important thing, however, from the point of view of coal specifications, is that the tests of the ash of February 3, 4, 5 and 6, when the regular station coal was used which gave a minimum of clinker trouble, yield results which fall in the doubtful region and would therefore be rejected in coal specifications based on fusing temperatures alone.

Additional indications of the liability to clinker trouble may be obtained from the range of temperature during bending and from the appearance of the bent cone. The cones of the ash which gave most trouble had a very fluid constituent which ran down to the tip of the cone and also upon the supporting plate and gave the appearance shown in Fig. 3; those giving least trouble were as in Fig. 4. It would appear that the most fusible constituents will separate from the rest of the cone when it is very fluid, leaving a skeleton

FIG. 3 FUSED CONE WITH VERY FLUID CONSTITUENT

FIG. 4 NORMAL FUSED CONE

which does not bend until its own fusing temperature is reached; that is, with the kind of ash which gives most trouble, the Seger cone method fails as a result of the separation of the more fusible from the less fusible constituents.

It is possible to accept the appearance of the bent cone as a partial indication of the clinkering behavior, and it may be possible to predict the behavior of an ash from that indication combined with the fusing temperature. The range of temperature during bending may also possibly be used. The range varies from 15 deg. to 55 deg. cent. in the tests given in Table 1; in other tests by the writer it has amounted to as much as 140 deg. cent. There seems to be a very close relation between this range and the viscosity of the melted cone. The ash cones of February 10 and March 5 show the smallest range and they also show greater fluidity (Fig. 3) than any of the other cones. It should be noted, however, that there is a liability to error in observing the initial and final bending temperatures, which is not less than 10 deg. cent. so that an observed range of temperature of 30 deg. may actually be anywhere from 10 deg. to 50 deg. cent.; it is necessary to make several determinations in order to get the range with reasonable certainty. The appearance of the melted cone is consequently more valuable than the range of fusing temperature.

TABLE 2 MELTING TEMPERATURE OF ASH AND FIRE ROOM RECORD OF CLINKERING

Date	Melting Temperatures Deg. Cent. (Fahr.)		Amount and Character of Clinker
	Initial and Final Bending	Range	
Feb. 3	1350–1395 (2462–2543)	45 (81)	Light
4	1360–1400 (2480–2552)	40 (72)	Light
5	1360–1400 (2480–2552)	40 (72)	Light
6	1340–1380 (2444–2516)	40 (72)	Light
10	1360–1375 (2480–2507)	15 (27)	Hard, excessive; 50 per cent of grate
13	1350–1395 (2462–2543)	45 (81)	Excessive to moderate; large clinker
Mar. 3	1370–1420 (2498–2588)	50 (90)	Not much, but very hard and isolated
5	1350–1370 (2462–2498)	20 (36)	Excessive; 75 per cent of grate
11	1355–1380 (2471–2516)	25 (45)	Heavy
13	1340–1395 (2444–2543)	55 (99)	Heavy
17	1430–1480 (2606–2696)	50 (90)	Light
24	1420–1450 (2588–2642)	30 (54)	Very little
26	>1500 (>2732)		Light, hard
Apr. 8	1335–1370 (2435–2498)	35 (63)	Excessive; very hard, 18 to 20 in. in V and thick

The investigations of the writer seem to show that under the conditions of combustion at the L Street plant of the Edison Electric Illuminating Company of Boston a coal with a fusing temperature (final bending) below about 1400 deg. cent. (2550 deg. fahr.) will probably give trouble if the ash has a fluid constituent; whereas, it will not give trouble above about 1380 deg. cent. (2516 deg. fahr.) if the ash is viscous. This conclusion would require further investigation with many other coals before it could be accepted even for this particular plant; naturally it cannot be applied to plants with different operating conditions.

DISCUSSION

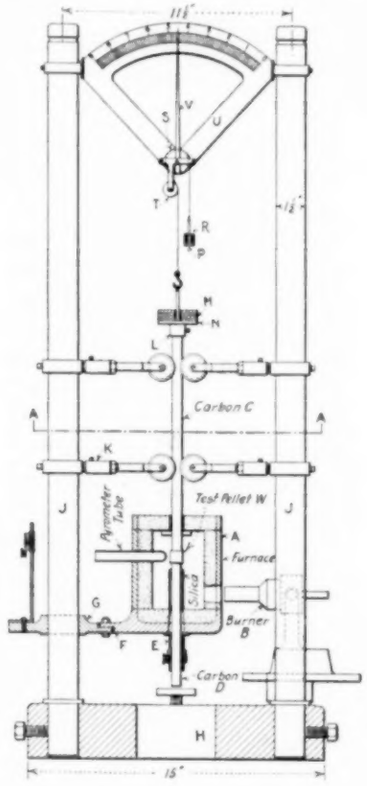
F. C. HUBLEY,[1] referring to the author's statement that a satisfactory laboratory test for clinkering should indicate viscosity as well as melting temperature, said it would probably be well to go further and state that such a test should indicate viscosity at any temperature throughout the softening range, and furthermore it should be of such a positive and definite nature that results from the same sample but from different laboratories, would agree closely. In searching for a more definite form of test than the various cone methods present, the writer finally adopted a test in which the collapse of an ash cylinder, under a slight vertical pressure, due to softening, is plotted against increasing temperature to form a curve, the shape and extent of which apparently present a complete picture of the nature and position of the softening range of the ash under test. The ash cylinder is formed without the use of a binder, from the completely incinerated pulverized ash, in a press exerting 30,000 lb. pressure per sq. in. on the cylinder.

Mr. Hubley gave a description of a fusiometer, which after experimenting in the construction of various designs of this instrument, has been adopted in the form shown in Fig. 5, as being best suited, mechanically speaking, to carry out the proposed fusion tests. A test pellet *W* is held centrally in the furnace *A* by carbon rods *C* and *D*, which are ordinary arc lamp carbons ½ in. in diameter. Rod *D* is held by a clamp *E* to the bottom of the furnace body and rod *C* and weights *L* and *N* are free to move vertically, carrying in this particular instrument, weights designed to exert a unit pressure of 1.5 lb. per sq. in. on the pellet. This rod is held on the center line of the instrument by four guide wheels and a silk cord over a pivoted pulley connects this rod and weights with a counter weight *P*. A pointer *V* is fixed to this pivoted pulley and indicates on a scale on plate *U;* the pulley is 1 in. in diameter and the pointer 6 in. long, so that any vertical movement of the carbon

[1] P. O. Box 202, Cynwyd, Pa.

rod C due to softening of the test pellet W, is magnified twelve times on the scale, the total collapse of a pellet $\frac{5}{8}$ in. in height being indicated by a movement of the pointer over $7\frac{1}{2}$ units on the scale. The several parts of the instrument are supported on two $1\frac{1}{2}$ inch diameter rods, fixed in a heavy cast iron base. This construction is considered necessary to obtain proper rigidity of the fixed points.

In experiments carried out by the writer, a gas-heated



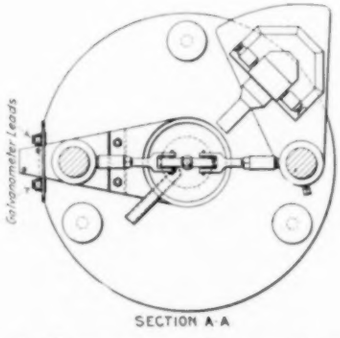


FIG. 5 ELEVATION AND PLAN OF FUSIOMETER

furnace was used. Regarding the time to make tests, eight tests, including making of pellets, were performed in three and one-half hours, averaging 26 min. per test. This time compares favorably with the time required to make a proximate analysis or a B.t.u. determination on fuel. During this performance the carbon rods were reduced from $\frac{1}{2}$ in. in diameter to $\frac{3}{8}$ in. in diameter at the pellet. Frequent replacement of these rods may be made since their cost is negligible.

Mr. Hubley explained the method of making the test and stated that, with the ash pellet and carbons in the position shown, and the pointer V adjusted midway between zero and 1.00 on the scale, the furnace is gradually heated at the rate of from 50 to 100 deg. fahr. per minute, simultaneous temperature and scale readings being made at one-half minute intervals. As the heat is increased negative movement of the pointer will indicate carbon expansion up to a temperature where first softening of the ash pellet is indicated by a positive movement of the pointer. The experiment is continued till final collapse of the pellet is indicated on the scale. These results if plotted, the temperatures as abscissae and the pointer movement as ordinates, produce a curve, an ordinate of which at any point is a measure of the relative rate of softening of the ash pellet at that temperature.

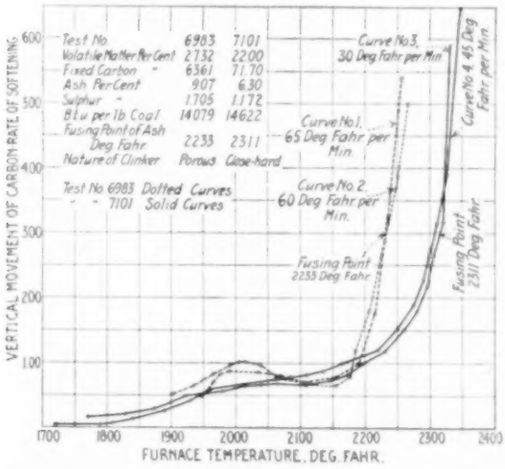


FIG. 6 ASH FUSION TESTS ON MIDDLE PENNSYLVANIA COALS WITH FUSIOMETER

He stated that the length of the softening range, and its position on the temperature scale in relation to the working temperature range of a boiler fire, as well as the increasing rate of softening, whether gradual throughout the range (indicating high viscosity), or very slight for most of the range, followed by a sudden collapse, are the factors in the fusiometer results which must be considered in predicting the probable clinkering action of a coal in a boiler fire. A long range ash with a slow but steady increase in softness, *apparently indicated by the gently sloping curve*, is productive of the close gummy clinker of high viscosity. This type, provided the softening range coincides approximately with the working temperature range of the boiler, produces the greatest losses from clinker formation in a boiler fire. This refers more particularly to stokers in which the fires are cleaned at regular intervals by a dropping of the back grates.

The other type of ash fusion is a short range spongy porous formation of low viscosity, which if it does not occur too low on the temperature scale, can be handled with ease in the boiler fires. From a comparison of boiler house results with a large number of tests made, the fusiometer curve for this type of fusion appears to be distinguished by a most decided downward dip in the curve just prior to final softening.

Mr. Hubley pointed out the fact that the term "fusing point" is misleading and indeterminate, while "fusing

range" of a substance can be determined with exactitude. For purposes of relative comparison, however, an arbitrary point in the fusing range may be selected and called the "fusing point" of the ash. For this point in the case of the fusiometer results, he suggests the temperature at which the pellet has collapsed due to softening, to one-half of its original height.

Mr. Hubley discussed several curves developed from a number of ash tests, using this instrument, together with boiler house reports in regard to the nature and extent of clinker formed under actual operating conditions. He showed tests of two samples that indicated a wide variation in the viscosity of melt between ashes fusing at approximately the same temperature, and pointed out the futility of using only the relative ash "fusing points" to grade

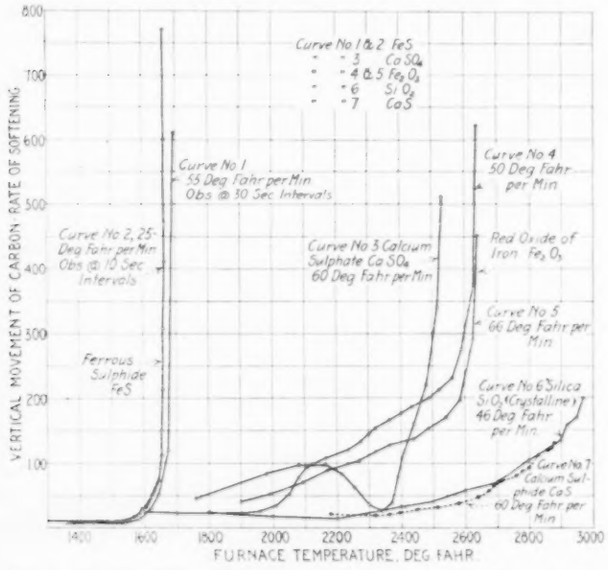

VERTICAL MOVEMENT OF CARBON RATE OF SOFTENING
FURNACE TEMPERATURE, DEG FAHR
Curve No 1 & 2 FeS
" " 3 Ca SO4
" " 4 & 5 Fe2 O3
" " 6 Si O2
" " 7 CaS
Curve No 1 55 Deg Fahr per Min Obs @ 30 Sec Intervals
Curve No 2, 25 Deg Fahr per Min Obs @ 10 Sec Intervals
Curve No 3 Calcium Sulphate Ca SO4 60 Deg Fahr per Min
Curve No 4 50 Deg Fahr per Min
Red Oxide of Iron Fe2 O3
Curve No 5 66 Deg Fahr per Min
Ferrous Sulphide FeS
Curve No 6 Silica Si O2 (Crystalline) 46 Deg Fahr per Min
Curve No 7 Calcium Sulphide CaS 60 Deg Fahr per Min

FIG. 7 FUSING RANGE OF ASH CONSTITUENTS USING FUSIOMETER

coals as to their probable freedom from clinkering trouble, without considering also viscosity and length of softening range (see Fig. 6). One of these coals formed a porous clinker easily broken up and the other a close gummy clinker difficult to remove from the firebox. A number of similar graphical records of tests were shown that clearly indicated the characteristics of the coals tested.

Mr. Hubley showed in Fig. 7 curves for calcium sulphate and the red oxide of iron that are interesting, since they represent, in shape, the two extremes of coal ash fusion. Of the total number of ash samples tested by this method, a large percentage of those melting between 2100 and 2500 deg. fahr. show indications in varying degree of the dip in the calcium sulphate curve. Also, a coal ash producing a fusion curve similar to that of the sulphate, shows a low viscosity of meld and will produce a porous brittle clinker easily broken up and removed from the fire box; while an ash producing a curve similar to the ferric oxide fusion, indicates high viscosity and the production of a tough gummy clinker difficult to break up and remove from the fire box.

He showed that the first type of fusion, while causing no excessive delay at cleaning periods, is productive of dirty fire and a high percentage loss of carbon in the ash pits. The second type not only causes delay at cleaning periods, but increases the wear on the grate bars and brick work, in addition to cutting down the capacity and efficiency of the boiler as a whole. One of the effects of this type of fusion is to arch over the back grates on a stoker, preventing the admission of air necessary to economically burn down a fire preparatory to cleaning.

The expansion of a pellet of calcium sulphate, between 2100 and 2350 deg. fahr. or prior to the melting point, would indicate the evolution and release of a gas between these temperatures. He is still seeking an explanation of this occurrence, since this curve was reproduced a number of times both in shape and position on the temperature scale; first in the presence of reducing agents and later with the carbon rods covered with platinum ferrules and an excess of air in the furnace gases.

He referred to Fig. 8, which shows fusiometer tests on a three-car shipment of coal from a certain mine and illustrates a number of important points bearing on the clinker problem.

First. Curves 1 and 2 show the accuracy which may be obtained on duplicate samples from the same ash. He

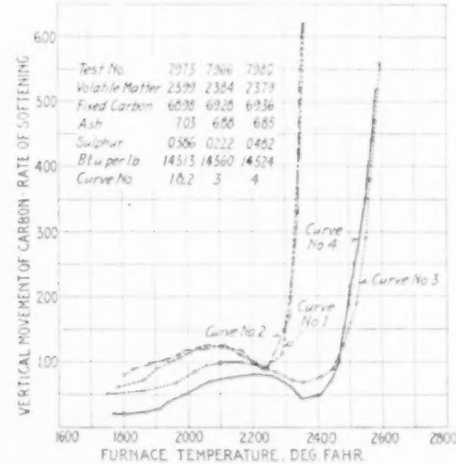

VERTICAL MOVEMENT OF CARBON RATE OF SOFTENING
FURNACE TEMPERATURE, DEG FAHR
Test No 7975 7966 7960
Volatile Matter 2599 2384 2373
Fixed Carbon 6698 6928 6936
Ash 703 688 685
Sulphur 0886 0222 0462
Btu per lb 14513 14560 14524
Curve No 1&2 3 4
Curve No 4
Curve No 3
Curve No 2
Curve No 1

FIG. 8 SOFTENING RANGE OF BITUMINOUS COAL ASHES FROM FUEL USED IN TAYLOR STOKERS

believes that if complete incineration and thorough pulverizing and mixing of the ash sample occurs previous to testing, the accuracy shown in Curves 1 and 2 and in some of the previous illustrations may be obtained in each case. It follows therefore that two different laboratories, both using this method, could be expected to show a correspondingly close agreement in results obtained, a circumstance which appears to be conspicuously lacking where modifications of the Seger cone method are used. This is an important point if the clinkering characteristic of fuel is to be regulated by a specification based on the method of determination of softening temperature.

Second. Fig. 8 also illustrates that three cars of coal from the same mine, although showing the most remarkable uniformity as to proximate analysis, sulphur content and heating value, will vary considerably as to fusibility of ash. It has been found at times that the ash in the roof or large partings in a vein will vary considerably in fusibility with the true ash of the coal, but in this case it would appear,

from the uniformly low ash obtained in each car, that in this vein or mine the true ash itself varied in fusibility.

Third. As actually tested, these three cars were used in Taylor Stokers with Rust boilers operating at 180 per cent of rated capacity. At this rate, fuel bed temperatures as high as 2800 deg. fahr. have been observed with the Fery radiation pyrometer, with an average of over 2700 deg. The boiler room reported as follows: "This coal proved to be unsatisfactory inasmuch as it clinkered to a troublesome extent. Coal contained in Test No. 7973 appeared to make a much harder clinker than either of the other cars." It would appear therefore that, knowing the approximate fuel bed temperatures under which this coal was to be consumed, the degree of probable clinker trouble in using this fuel under these load conditions could have been predicted from the curves in Fig. 8. The fact that a porous easily removed clinker was not formed (as would be ordinarily indicated by the dip in the curves previous to melting) is probably due to the high fuel bed temperature at which this fuel was consumed, a temperature far above the final melting temperature of any one of these ash samples. In other words, had fuels represented by Curves 3 and 4 been consumed at fuel bed temperatures of 2500 deg. fahr. or under, a porous easily removed clinker would probably have been formed. The same can be said of fuel represented by Curves 1 and 2 for fuel bed temperatures of 2300 deg. fahr. or under. For Babcock & Wilcox boilers with Roney Stokers, 2500 deg. corresponds to a load of approximately 150 per cent of rating and 2300 deg. to 110 per cent of rating.

It has often been noted, in a boiler fire room, that in burning a fuel which produced a not too troublesome clinker, if for one reason or another the fire is not thoroughly cleaned at one fire-cleaning period, the clinker not removed at this period will give excessive trouble in removal at the next succeeding period. One sample shown could give trouble of this nature, not because of the reduced temperature at which this ash re-fuses but due to a change in viscosity of the re-fused mass.

Basing an opinion on this form of test, the writer suggests the following specification: The pellet shall not have collapsed due to softening, to more than one-half of the original height at a temperature *T*, and in addition, shall not show a collapse of more than one-eighth of the original height due to softening at a temperature 300 deg. fahr. under temperature *T*. The first part of this specification will limit the final fusion, while the second part is intended to control viscosity and avoid the sloping curve shown in Tests No. 7124, Fig. 7 and 7201, Fig. 6.

Referring to Fig. 9, the position of the line A-A or the fixing of temperature *T* must vary for plant conditions. It is obvious that the buying field for steam coal will be restricted or broadened according as the temperature T is raised or lowered, so that the fixing of this temperature must be governed by the value which a plant management places on loss of boiler capacity, and risk of steam failure against the saving made in purchasing the cheaper fuel.

O. W. PALMENBERG[1] offered a method of testing which he follows and which he has found to give satisfactory results when comparing laboratory tests with results as obtained in practice. He uses a gas muffle furnace heated with a double blast Meker burner and by this means can attain temperatures ranging as high as 3000 deg. fahr. The rate of heating is under good control and the temperatures required can be obtained conveniently. The muffle is uniformly heated, the flame passing around it, and has a door with a small opening for observation. The temperature readings are made with an optical pyrometer which is standardized in the usual way with an Amyl Acetate flame every time before making a fusing test, care being taken to have conditions as nearly alike as possible.

The coal ash which has been burned free of carbon and heated to insure oxidation of the iron, is made into a round thin cone 1½ to 2 in. high weighing about one gram or less. This form is placed upon a thin piece of Battersea fireclay in a vertical position and set in the middle of the muffle. After heating the furnace, the blast is applied rapidly at

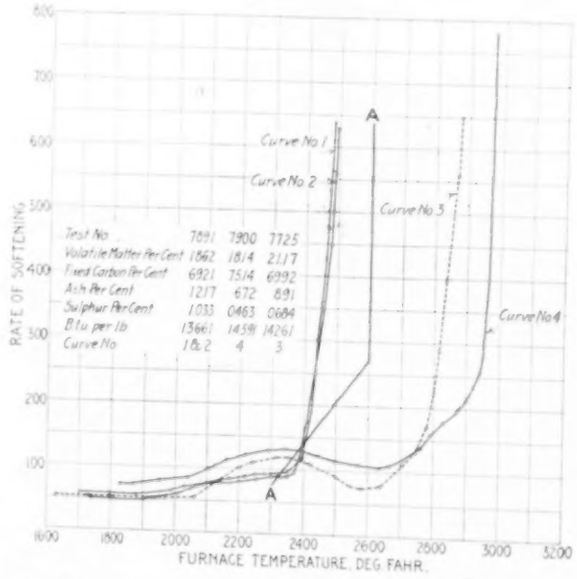

RATE OF SOFTENING
FURNACE TEMPERATURE, DEG. FAHR.
Curve No 1
Curve No 2
Curve No 3
Curve No 4
A
A
Test No 7891 7900 7725
Volatile Matter Per Cent 1862 1814 2117
Fixed Carbon Per Cent 6921 7514 6992
Ash Per Cent 1217 672 891
Sulphur Per Cent 1033 0463 0684
B.t.u. per lb 13661 14598 14261
Curve No 1&2 4 3

FIG. 9 SOFTENING RANGE OF BITUMINOUS COAL ASHES FROM FUEL USED IN TAYLOR STOKERS

first until the temperature is nearly that at which the form begins to bend. Then the heat is regulated carefully and readings made every five minutes or oftener depending upon the rate of heating; care must be taken to have the heating carried on slowly. As soon as the cone shows signs of bending the temperature is noted and the operation continued until the cone has completely bent over and touched the plate, the temperature at which the point touches the plate being called the fusing temperature.

He has made a large number of fusing tests by this method, as regular routine laboratory work in connection with coal analyses, and considers the information on fusing temperature tests on coal ash of the greatest importance. While it may be true that the fusing test does not at times agree with results as obtained in practice, this may be said of any other kind of laboratory test, but when a practical test is at variance with a laboratory test the cause may usually be found and accounted for. The laboratory test gives an important clue as to the value of a coal for certain furnace conditions which cannot otherwise be readily and conveniently ascertained.

In reply is Prof. Marks' statement "relative to the separa-

[1] 50 East 41st St., New York.

tion of the more fusible constituents and thereby leaving a skeleton which fuses at a higher temperature," Mr. Palmenberg said that this difficulty does not seem to present itself when the cones are made long and thin, at least not to interfere with the tests. If the ash is thoroughly ground and mixed he believes that a complete fusion of the whole mass should take place. Furthermore, by making the ash into a long and thin form, it tends to help retain its shape during the whole time of heating and gives tests that can be duplicated to a fair degree of accuracy. The weight and height of the form does not make much difference with most coals but it is no doubt a good practice to have a standard size so that the results may be compared.

He said that whether a small amount of carbon left in the ash has any appreciable effect upon the fusing temperature will no doubt depend upon the conditions of the test and the nature of the coal ash; he had found that as much as 10 per cent carbon had no effect. If much iron is present the carbon may influence the test, but as a rule all the carbon will have burned off before fusion takes place. It is of course advisable to have no carbon present in the cone so that no reduction of the Fe_2O_3 can take place thereby raising the fusing temperature.

In regard to Mr. Hubley's statement about the relation of the fusing test to the iron oxide and sulfur, he said they seem to bear out in a general way further investigations of his that high iron and high sulfur coals give a low fusing ash, but low iron and low sulfur coals do not necessarily produce high fusing ash. The tests referred to were made on coals from Pennsylvania and as they all bear a certain relation to each other there would naturally be a corresponding relation in the fusing tests; when coal from other sources are tested the findings are very different, so that the iron or sulfur content does not always give an indication of the fusing temperature of the ash. He had recently tested the ash of a coal from Texas in which the iron oxide (Fe_2O_3) was 10.76 per cent and had a fusing temperature of only 2138 deg. fahr.

As a further illustration to show the variable influence of iron oxide and sulfur, he presented records of tests on two lots of coal coming from Cambria county, Pa., mined from the "B" vein, the mines being about 50 miles apart. The coals in the first group represented samples taken from the face of the vein at various parts of the mine, the coals in the second group represent samples taken from deliveries. This latter coal is noted for its uniformity in quality, being prepared in a careful manner at the mine on a picking belt before being dumped into the railroad cars. In comparing the results of these two coals it is found that the first group has an ash fusing more than 100 deg. higher than that of the second group, although the Fe_2O_3 is somewhat higher and the sulfur about the same. There seems to be no strict relation of the iron and sulfur to the fusing test in either case. The results on the first group coal showed plainly the variations obtained on samples taken from the face of the vein, whereas the average samples obtained in the second group coal shipments showed few variations. The second group coal samples being obtained from a larger bulk gave a more uniform mixture of the ash constituents. These fusion tests covered a period of many months and therefore the various determinations were made under different conditions.

Mr. Palmenberg referred to a few analyses that he had made on the ash samples before and after fusing, which indicated an increase of Fe_2O_3 in the fused cone and this he explained by the fact that these coal ashes lose some of their constituents during heating and thereby increase the ratio of the iron to the other parts. He said that the volatile constituents may be CO_2 from the carbonates and H_2O from water of combination in the silicates. The ash samples were subjected to heating in a flat silica dish with a blast flame, prior to being made into a cone for fusing, the object being to assure complete oxidation of the iron.

To show the accuracy with which fusing tests may be made, he presented records of a few duplicate determinations and Seger cone tests which he had chosen from a number of tests made in routine work. He commended Prof. Marks for the splendid and convincing manner in which he has pointed out the variable conditions met with in the work of obtaining the fusing temperature of coal ash and hoped that they may lead in the near future to the selection of a standard method for this important and valuable kind of work.

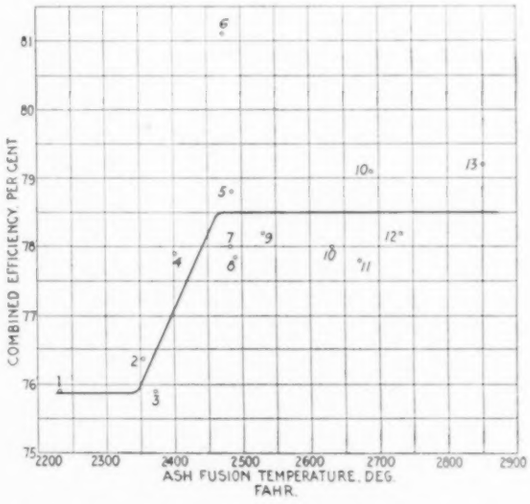


FIG. 10 EFFICIENCY VS. ASH FUSION TEMPERATURE

O. P. HOOD[1] stated that laboratory methods should work towards the end that a laboratory treatment of a small sample will indicate the results that can be expected from that coal in actual practice. He said there will always be lack of agreement with commercial results until furnaces and the treatment of fires are as carefully standardized as are the laboratory methods. Calorimetric determinations have been of great value, but the potential ability of the coal thus disclosed is not made available in the furnace because of numerous unfavorable factors. He finds these factors each require careful study and may some day find their place in coal specifications. The matter of clinkering is one of the most important. If, he said, the seriousness of the clinker difficulty holds some definite relation to the fusing temperature, then a laboratory determination of fusibility becomes desirable. It can not as yet be said that such a relation is established in any large sense although the assumption seems reasonable. Some coals with a low

[1] Chief Mechanical Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.

fusing temperature of the ash give no trouble with clinkering. Some coals with a high fusing temperature give trouble under certain methods of handling. He stated that there is practically no knowledge available as to the relation between laboratory results and clinker formation under furnace conditions, and that the U. S. Bureau of Mines has consistently opposed the use of fusing-temperature tests in the purchase of coal under specifications by the Government until a thorough investigation of the subject should disclose the relation between these laboratory tests and actual furnace conditions and clinker troubles.

Realizing that the results obtained for fusing temperature under different conditions of rate of heating, oxidation, and reduction would vary greatly, and that an extended investigation with a view to standardizing the laboratory test was necessary before a comparison with actual clinkering tests in commercial furnaces could be undertaken, an investigation has been conducted by A. F. Fieldner and A. E. Hall in the Pittsburgh laboratory of the Bureau of Mines, and Professor Hood stated their conclusions from the work done before July 1, 1914, as follows:

A complex mixture of oxides and silicates like coal ash has no definite melting point. On heating a sample of coal ash it first cinters, then gradually softens into a more or less viscous slag. Hence in assigning a "fusing" or softening temperature we can only take some point or temperature range where the material reaches a certain stage of softening or degree of fluidity. The temperature at which the visible softening takes place is affected by a number of factors:

1. Oxidizing or reducing atmosphere;
2. Fineness of ash;
3. Shape of test piece;
4. Rate of heating.

The effect of these factors on the softening of ash molded into small pyramids similar to Seger cones, has been studied, and the results prepared for publication.

It is evident from the results obtained thus far that variations in the conditions under which laboratory tests are made may cause variations in the so-called fusing temperature of several hundred deg. cent., and that the fusing temperature of the ignited ash of a coal is not the only factor in the clinkering properties of the coal.

Prof. Hood pointed out that, contrary to Prof. Marks' results on the effect of oxidizing and reducing atmospheres, Fieldner and Hall do not conclude that the fusing temperature in reducing atmospheres is always higher than in oxidizing atmospheres. Their investigation, which covered some fifty different coals, showed in some cases higher results in reducing atmospheres and in other cases lower results. The difference varied with the composition of the ash and the extent of reduction that took place in the test furnace. Furthermore, they do not conclude that the test should necessarily be made in an oxidizing atmosphere. Conditions in the fuel bed are variable. There are regions where ash forms in the presence of reducing agents. Incandescent carbon, CO, hydrogen and hydrocarbon gases are good reducing agents. The possibility of clinker formation under reducing conditions must therefore be considered. Keeping this in mind, the Bureau is making further investigations of the slagging of ash under the various possible fuel-bed conditions. The first step in this work is now being prepared for publication.

He further pointed out that, after a consistent laboratory method is devised whereby different laboratories can obtain comparable results there yet remains the correlation of these results with actual experience in the furnace to determine what value fusibility tests may have in coal specifications.

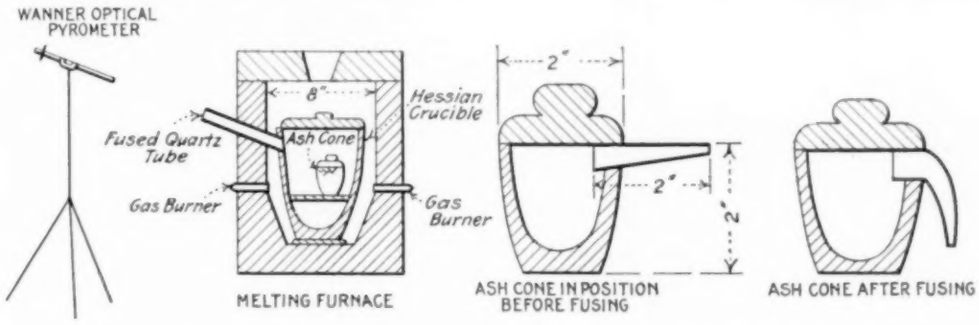


Fig. 11 Apparatus used in Determining the Fusibility of Coal Ash

E. B. Ricketts referred to a series of tests made to determine the value of coal clinkering and ash fusion data to the power plant manager in its effect on the efficiency and capacity of the boiler plant. The tests were made in the spring of 1914 on a 650 h.p. Babcock & Wilcox boiler fired by a Taylor stoker. The boiler output was maintained at about 825 h.p. throughout the test except for one hour when the boiler was forced to between 1250 and 1700 h.p. The boiler was cleaned before each test and the conditions were maintained as nearly constant as possible throughout the series of tests. Most of these tests were of 120 hr. duration. In all thirteen coals having ash fusion temperatures varying from 2225 to 2850 deg. fahr. were tested, the results of which are shown in Fig. 10. Mr. Ricketts pointed out that this curve is practically two discontinuous lines with a critical zone between 2375 and 2450 deg. fahr. Lowering the fusion point from 2375 to 2225 deg., or raising it from 2450 to 2850 deg. has no effect on the efficiency, thus leaving a zone of uncertainty of about 75 deg. where the clinkering effect is doubtful. This critical zone covers the errors in testing and differences in fire conditions.

Mr. Ricketts stated that the above curve probably covers all ordinary operating conditions for Taylor stokers, but it is easily possible that the critical zone for another type

of stoker may be at a different part of the curve. In applying the results of the above tests, he has evolved the following method of determining coal values: taking any coal, the cost and analysis of which is known, as a standard, the relative value of any other coal of known composition can be determined by the following formula:

A = B.t.u. per lb. standard coal × efficiency from curve

B = B.t.u. per lb. coal *X* × efficiency from curve

C = Cost per ton of coal of transportation to bunkers and disposal of refuse for each per cent of ash in coal

$$D = \frac{(\text{Per cent ash coal } X - \text{per cent ash standard coal}) \times C}{\text{Cost per ton of standard coal in bunkers}}$$

Value of coal *X* in per cent of standard coal =

$$\left(\frac{B}{A} + C\right) \times 100$$

The above method of coal valuation differs, he stated, from those heretofore proposed in that the burning qualities of the coal are given proper weight and the detrimental effect of high ash is properly discounted.

Also the method used by Mr. Ricketts for determining ash fusion temperatures differs somewhat from that described by Prof. Marks. About two pounds of coal are coked in a crucible in a gas furnace for about an hour after which the lump of coke is broken up and a stream of compressed air is fed in near the bottom of the crucible for from two to three hours until the coke is all reduced to ash. When burning the coke down, care should be taken to keep the temperature below 1500 deg. fahr. so as to prevent premature fusion. The ash is then tested a small amount at a time with oxygen to make sure that all the carbon is consumed. It is of vital importance that no carbon be left in the ash as a small trace may cause results several hundred degrees too high. The carbon free ash is moistened with a little water and moulded in a paper cone 2½ in. long and ½ in. base. The cones are dried for five or six hours and then fused in a muffle furnace without removing the paper in which it was moulded. The cone is so placed that it overhangs the point of support about 1½ in. The point of fusion is taken when the cone reaches a 45 deg. position and is read on a Wanner optical pyrometer. (See Fig. 11.)

The question of correct melting point is in Mr. Ricketts' opinion one of minor importance so long as the results obtained are consistent. With the above described method they are able to check the same sample of coal within a few degrees and his observation of the action in the fire room of several hundred cargoes of coal from some twenty-five different sources on which ash fusion tests have been made, has consistently confirmed the results given in the test curve.

P. F. WALKER called attention to conditions under which coal may give trouble, depending very largely upon the method of handling. He referred to a situation where he had had trouble in the use of a coal with a very large amount of ash, on both hand fired grates and with stokers. He had found, however, that the firemen might be taught to handle their fires so that the difficulties are vastly different in the one case from those in the other.

ROGER DEWOLF questioned a point in the early part of Prof. Marks' paper in which a non-adhering clinker was referred to. He stated that if an ash does melt and form a non-adhering clinker, it gives very little trouble, as there is a very great difference between various coals in this regard. He asked if any work had been done that would indicate a method of determining the adherent qualities of the clinker.

THE AUTHOR said that Mr. Ricketts, in speaking of the work of the New York Edison Company, showed a curve of fusing temperatures, and their relations to clinkering troubles. My own investigations would, apparently, give just about the same results but there is this difference: I have exchanged samples of ash with the New York Edison Laboratory, and my fusing temperatures come out consistently about 200 deg. higher than those obtained at the New York Edison Company. I have calibrated my pyrometer by the melting point of nickel and by the use of the Seger cone, and I feel sure of my pyrometric work. They feel sure of their pyrometric work. Though we both come to the same conclusions, they are based on the indications of pyrometers which are strongly discordant.

F. C. HUBLEY, in speaking of this matter of discordant results between the New York Edison Laboratory and Professor Marks, said there is a rather interesting coincidence in this connection. We have Taylor stokers, forced draft, and very troublesome peak loads, a mill-load in other words, and we have specified 2700 deg. as the so-called fusing point of the ash. If you take the difference between Professor Marks' figures, I believe he stated 260 deg., and the average acceptable figure, specified by the New York Edison Company of 2450, you will obtain a figure of 2700 deg. fahr. I have personally measured the fuel bed temperature in Taylor stokers with a radiation pyrometer, with 200 per cent radiation, and for temperature of 2700 fahr. It would appear, therefore, as though the New York Edison Company have either misjudged the temperature of their fuel bed, or have been in error in the figures obtained in the laboratory.

SPAULDING-DRUM POWER DEVELOPMENT

BY JOHN A. BRITTON, SAN FRANCISCO, CAL.

Member of the Society

THE location of the Spaulding Dam is on the South Yuba River near Emigrant Gap. The drainage area is 120 sq. miles, and a dam 300 ft. high will ultimately be required to conserve the run-off. The water after being released from the dam will pass through six power houses; one of these, the Drum Power Station, is completed and has been in operation for nearly a year, and four have their foundations laid. A total head of over 4000 ft. will be utilized. After passing through the sixth power house, the water is to enter the irrigation system by means of which it will be possible to irrigate over 60,000 acres of land.

a As results were required from the development by the end of 1913, it was necessary to select such a method of construction as would ensure completion by that time, and reject anything that would not meet that condition.

It was at first proposed to build the dam from concrete made of crushed granite and a sand and gravel found near the dam. This local gravel would not stand the test of crushing strength, namely over 1000 lb. per sq. in. at ninety days, and therefore had to be rejected. Finally, a gravel deposit was selected on the Bear River near Colfax. This material was very well graded, clean, made excellent concrete and was

FIG. 1 GENERAL VIEW OF THE SOUTH YUBA RIVER GORGE, BELOW SITE OF THE SPAULDING DAM

The foundation of the Spaulding Dam was placed in November and December 1912, and the dam was "poured" between May and December 1913, so that the 150,000 cu. yd. in the dam was placed in less than nine months. The reservoir was filled on February 1, 1914, to an elevation of 225 ft. and Drum Plant was put in operation on November 26, 1913. The entire work was carried through ahead of schedule and estimates of costs were realized.

Features of the Spaulding Dam which will interest engineers and construction men are:

a The method of construction, especially with reference to obtaining speed of construction
b The variable radius arch design
c The expansion joints
d The drainage system
e The water control or discharge system

Abstract of paper presented at the San Francisco local meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on September 10, 1914.

located in such position that the desired speed of supply could be obtained. The material was loaded by steam shovel into 30 cu. yd. gondola cars and hauled to Colfax over the track of the Nevada County Narrow Gauge Railroad. The cars were dumped into large bunkers at an elevation of about 375 ft. above the bottom of the dam.

From the storage bunkers the gravel was conveyed by belt conveyors to service bins located over four one-yard Smith mixers. From thence, the concrete was carried by chutes to towers located over the dam and from these towers it was distributed by chutes to the part of the dam desired. For the lower part of the dam, the concrete was dropped through a series of baffles to the elevation desired, from whence it was carried by chutes to its destination. In falling through this set of baffles the mixing was materially aided. At the end where the concrete towers were located, after the dam had reached the grade of the chute from the mixing plant, the concrete was elevated by belt conveyors and distributed from other towers and chutes. The concrete was allowed,

as far as possible, to flow onto the dam by its own weight—like a lava flow—and only five men were required to distribute 1000 to 2000 yd. per day. The grade of the chutes was 5 in. per ft. and of the belt conveyors 18 deg. and 20 deg. The speed of the belt was about 420 ft. per minute and a 28 in. belt was used.

This is, I believe, the first concrete that has been successfully transported by belt conveyors. Successful transportation depends on a wide belt, well-troughed, and on keeping the belt clean. To clean the belt a rotating brush, a stream of water and a compressed air jet were used. A thousand yards of concrete per day were easily handled over a single belt, and tests showed as high as 200 yd. per hr.

The gravel mixture was tested hourly at the gravel pit and samples were again taken on the belt conveyors at the mixing plant. Any deficiency was made up by crushed rock, or sand as required. Three samples of the concrete were taken off the dam daily and these were tested at 7, 28, and 90 days, six months and a year. The location where sample was taken was marked on each, so that records of the strength of the dam at all points and of the increase of strength with age are available.

b The dam site immediately suggested an arched dam, as the walls of the canyon are solid granite and converge downstream. The scientific design of any structure demands that factors of safety throughout shall be consistent in order that a structure of uniform strength may result; and, since in building an arched dam across a river canyon, we are really building sections of a pipe spanning the canyon, in order to build a dam of uniform factor of safety from top to bottom, the thickness of the dam must vary with the width of canyon and with the head of water. These considerations lead to a design having a variable radius, increasing as the canyon becomes wider. This results in a structure having uniform elasticity, as far as possible, all parts of the concrete being strained practically to the same amount. The design is calculated for a strain of 24 tons per sq. ft., assuming all the strain to be taken up by arch action. Ultimately, the dam will be carried up to an elevation of about 300 ft.

The arch type of dam requires no more labor in building forms than does the single radius arch, although it involves more work for the instrument men in locating the lines. The increasing radius, as the canyon width increases, gives a natural batter to the front face, and the entire appearance of the dam is one of strength.

c Concrete will contract in setting and form cracks. In order to control the position of the cracks to prevent them from weakening the dam, radial contraction joints were located every 80 ft. along the length of the dam. The dam was therefore really built up of 80 ft. keystone concrete blocks, and the writer considers it advisable to use contraction joints in all high or long dams. These contraction joints may increase the initial leakage, but after the reservoir has been drawn down somewhat following the first filling and when the dam is at a low temperature, grout may be forced into all joints and leakage cut off.

d Although a drainage system is advisable in a gravity dam to prevent uplift due to hydrostatic pressure, it is not so necessary in the arched type of dam. One was provided,

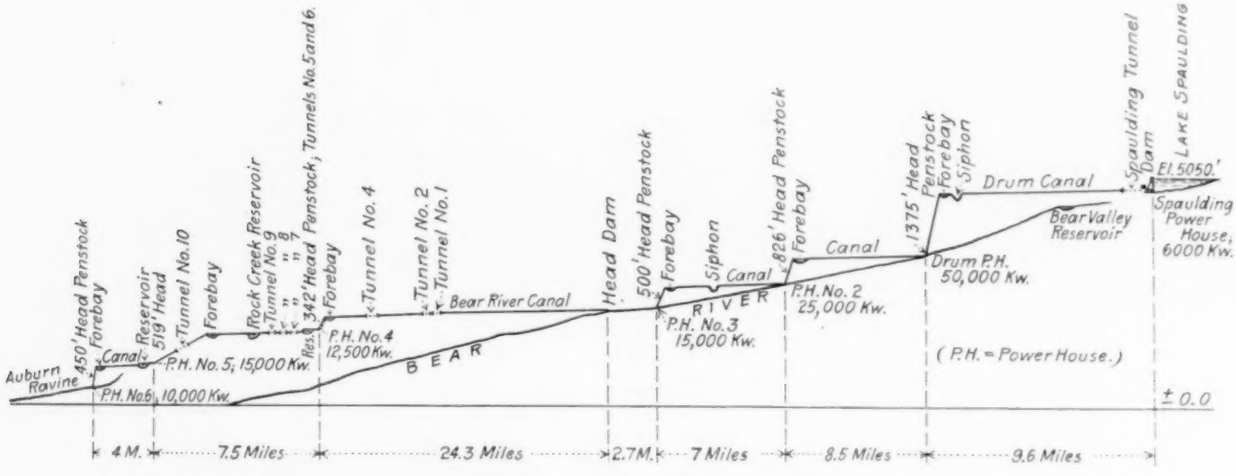


FIG. 2 PROFILE SHOWING LOCATIONS OF THE VARIOUS DEVELOPMENTS ON THE SOUTH YUBA AND BEAR RIVERS

however, in the Spaulding Dam, consisting of two parallel rows of holes running vertically from top to bottom of the dam and to bed rock.

A drainage tunnel was built in the dam following generally parallel to bed-rock, and a discharge tunnel connects with this tunnel to the rear of the dam. The main discharge tunnel from the reservoir is about 70 ft. elevation above the bottom. At an elevation of 100 ft. above this, a second outlet tunnel was built connecting with the first tunnel through an incline rise and giving in effect a gate tower with two openings. Near the upper end of these tunnels were placed 6 ft. steel butterfly valves, connected with the main tunnel by appropriate steel tapers.

At a distance of 694 ft. from the point of convergence of the upper tunnel rise and the original tunnel, a concrete bulkhead was placed, and a new tunnel was driven outward. The whole of this main tunnel to the gates was concrete lined and the last 120 ft. was reinforced sufficient to carry the total pressure that would exist with the reservoir level at 300 ft. in the ultimate dam.

After rising 13 ft. the lined tunnel enters a steel taper, which emerges into the operating chamber and ends in a cast steel manifold, to which are attached two 36 in. Allis-Chalmers pressure regulating valves on the side and a 72 in.

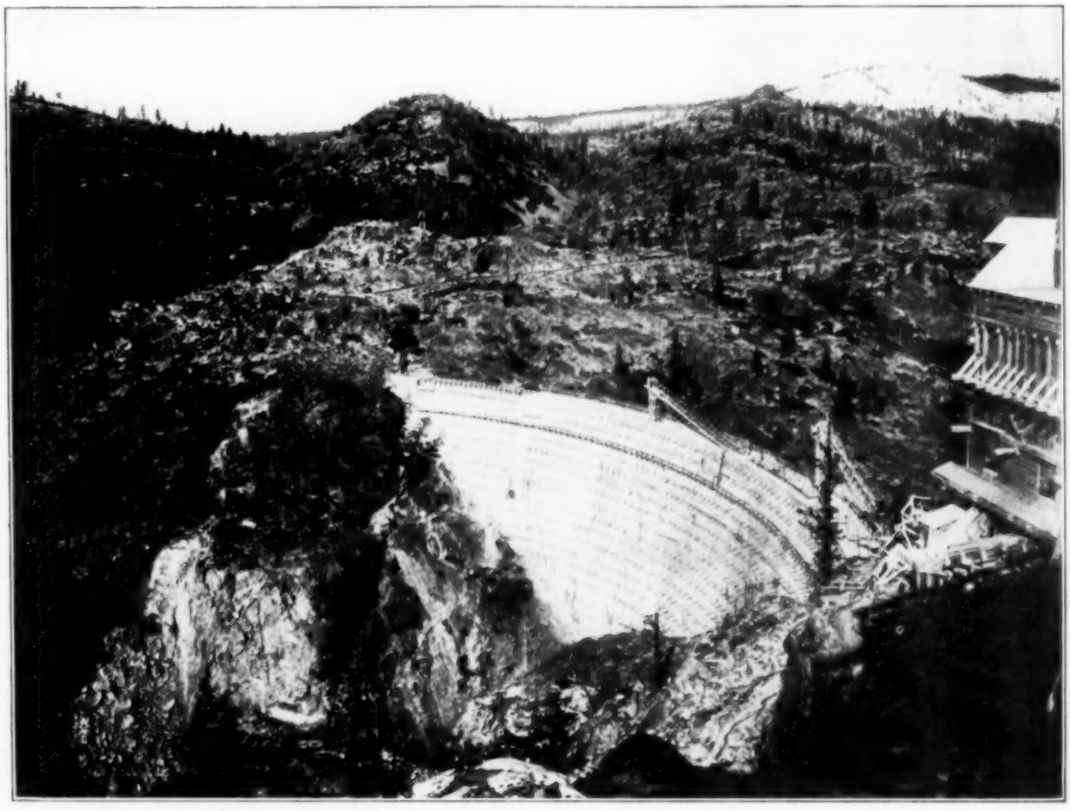


FIG. 3 DOWNSTREAM FACE OF SPAULDING DAM, SHOWING STEPS AND BOND RAILS PROVIDED FOR RAISING DAM TO 300 FT.

FIG. 4 VIEW OF SPAULDING DAM COMPLETED TO HEIGHT OF 225 FT., SHOWING ARCH, SPILLWAY AND CONCRETE PLANT

butterfly valve on the end. A variable head two runner turbine will later be extended beyond this butterfly valve, but at present the valve dead-ends this taper pipe while the water is drawn off by hydraulically-operated pressure regulators which each have a 36 in. clear opening, guarded by a 48 in. butterfly valve for emergency and repair purposes.

The valve closing the 36 in. port opening is a "mushroom" shaped or conical disc valve, rising up into the stream and being operated by a shaft connected to a disc of slightly larger area in a chamber above to which pressure is applied or withdrawn as needed. By turning handwheel on a screw thread of the shaft extended up through a stuffing box, the

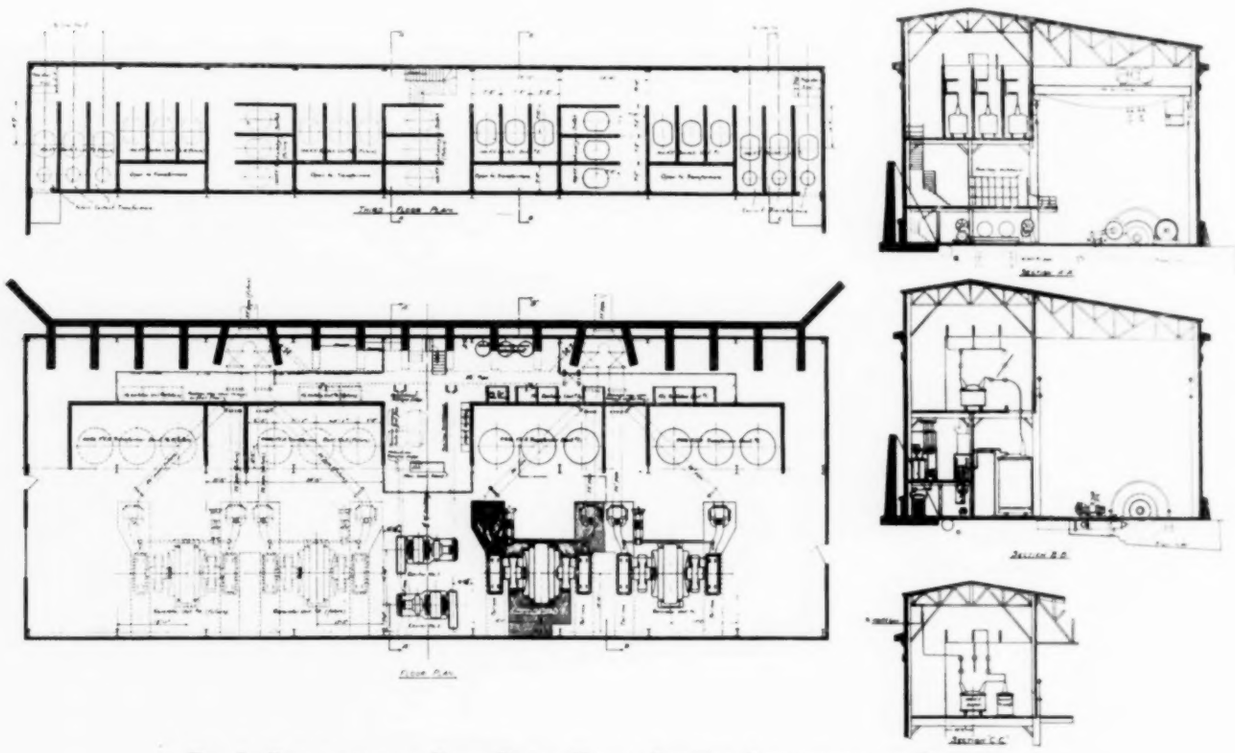


FIG. 5 DETAILS OF THE DRUM POWER HOUSE, SHOWING ARRANGEMENT OF EQUIPMENT

attendant can lock the gate at any position according to the flow required.

The valves discharge into steel draft tubes, imbedded in concrete, which turn the water out horizontally into a surge pit below the level of the main tunnel. They are now operating under a static head of 140 ft., and the hollow cone of water shooting out through the gate opening has a velocity of 93 ft. per sec., with no valve vibration.

It is proposed to install later at this place a turbine and generator, consuming about 5000 kw. from the static energy of the impounded waters as they are drawn into the Drum aqueduct, so that the turbine will become the control gate and the power now lost will be sent to the transmission system.

From the Spaulding tunnel, the water is carried 8.5 miles to Drum forebay by 7½ miles of earth canal, 2602 ft. of flumes, and 3600 ft. of siphons. The canal system begins at a small elevation above the South Fork of the Yuba River and follows the mountain side, swinging into the head waters of the Bear River and thence along a light grade of 1 ft. per 1000, finally coming to the end of a spur 1375 ft. above the Bear River, where the forebay is perched.

The length of canal is 39,631 ft., having five sections (in all 2602 lineal ft.) of box flume built at sharp ravines encountered in the length of canal. The canal averages 11 ft. in the bottom width, and 7 ft. in depth, with side slopes of ½ to 1 and 1 to 1, depending upon the formation. The ultimate capacity will be 350 cu. ft. per sec. with an average of 7 ft. depth of water. The canal is broken in two places where siphons are used. The first siphon is a combination of 96 in. wood stave and 84 in. steel tube passing around the Tahoe Forest Reserve, and having a length of 1868 ft., with a maximum head of 237 ft. The second or Drum siphon crosses a draw just before reaching the forebay; it has a length of 1888 ft., is 102 in. in diameter, and has a maximum head of 128 ft. Altogether, the canal required 8511 linear ft. of masonry rock wall and 16,313 linear ft. of dry rubble wall.

The Drum forebay is a large regulating reservoir, gouged out of the top of a hill having an area of 20 acres. It is perched 1375 ft. above the Drum power house and is a lake of 444 acre ft. capacity with a depth of 34 ft. of water.

The forebay dam was constructed entirely of earth and clay taken from within the bounds of the dam. The excavated materials were handled direct by wheel- and fresno-scrapers or were plowed and loaded through traps, or directly by steam shovels into wagons and hauled to the site on the dam. The materials were well worked together by harrowing, rolling and wetting after being freed of all rocks. The latter were used in the 30 ft. rip-rap facing of the inner slope.

After the completion of the forebay dam, which is 230 ft. wide at the base and 54 ft. high at its maximum section, and

contains 266,219 cu. yd. of materials, the bottom and sides were puddled with a good quality of clay found within the enclosure.

The spillway is just back in the canal from the forebay. It is 75 ft. in width. A maximum depth of 1.75 ft. overflow would be required to care for 400 sec. ft.

The waters of the forebay are brought to the power station through a steel pipe 72 in. in diameter which will ultimately be duplicated. This line is 72 by ¼ in. riveted steel at the intake, diminishing to 52 by 1¼ in. at the power house where the static head of water is 1375 ft. The length of this penstock is 6282.2 ft., having a net weight of 2,920,000 lb.

The penstocks terminate in cast steel Y-pieces, each branch being again divided by secondary Y-pieces. The piping is so arranged that three units may be fed from either penstock. The usual method of operation will be with each penstock supplying two main units.

The main gate valves are of cast steel construction, with single parallel faced discs arranged to withstand pressure from either direction. They have 36 in. openings and are operated by reversible impulse water motors. The special fittings are all of cast steel, while the straight connecting pipes are of riveted steel. The connecting pipes were fitted in place after the Y-pieces and nozzle bodies had been set, and thus perfect alignment of all parts was secured without forcing any part into place with the attendant possibility of setting up stresses in the parts other than those caused by the water pressure.

At Drum power station, on the south bank of the Bear River, a site for a power house was secured by sluicing 40,000 cu. yd. of hill slope and finally blasting into bed rock for a site 100 ft. by 500 ft. long.

The erection of a reinforced concrete and steel building to house four 12,500 kw. generators was completed in November 1913. The initial installation of two 12,500 kw. generators was made and the same were "thrown" into service November 26, 1913.

The main water wheels are of the single jet impulse type and each develops a maximum of 10,000 h.p. at normal speed of 360 r.p.m. It would be difficult to obtain a greater output at this speed and head with high efficiency. The wheel centers are of the double disc type and the buckets are bolted to the discs with the "chain" arrangement.

The governors, which are of the oil pressure type, actuate the deflecting nozzles. The governing is simple and may be operated at any desired speed with perfect safety. The size of the jets is controlled by needle valves which are operated by motors controlled from the switchboard. With a little attention on the operator's part, this combination permits very good economy in the use of water and very good governing with a high degree of safety and simplicity.

Special attention was given to securing a low temperature rise of the main generators, and to devising a rotor construction which would withstand the high stresses set up under runaway conditions. Exceptionally good ventilation is secured by enclosing the generators and bringing all the air into the machine from outside the building. A rotor of great strength is obtained by building up the hub of the rotor of steel discs. Pressing these hubs on to the shafts was avoided by placing the entire hub in a tank of water which was brought up to the boiling point and held there until the rotor was thoroughly heated. This treatment expanded the bore of the rotor by about 20 thousandths of an in. The shaft, which was 8 thousandths larger than the bore of the rotor at normal temperature was simply lowered into the rotor, there being about 12 thousandths to spare. The water wheels were placed on the shaft by the same process. The assembled revolving parts weigh about 83 tons. The flywheel effect of these parts is over 1,750,000 lb.-ft. squared, and the energy stored in them when running at normal speed is over 38,500,000 ft.-lb.

A double circuit 110,000 volt transmission line is provided on steel towers, of which there are 730 in all in place. The initial single circuit extends 110 miles westerly from Drum power house to Cordelia sub-station, which is the load center of Pacific Service. From this point, the power is distributed radially at 60,000 volts to the cities and valleys

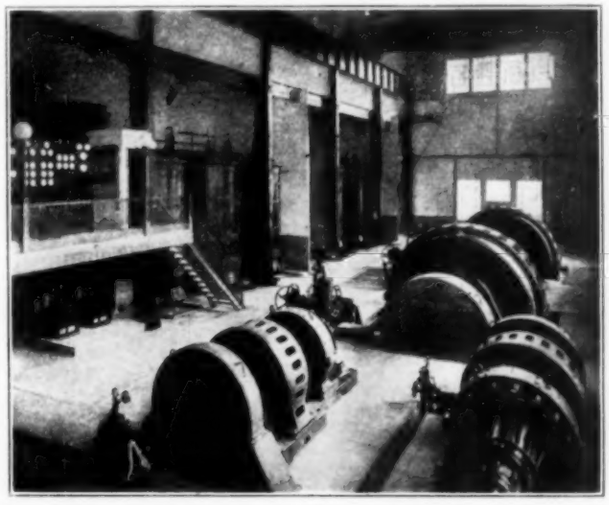


FIG. 6 INTERIOR VIEW IN THE DRUM PLANT

surrounding the bay. The standard spacing of towers is 800 ft. centers, with 30 ft. minimum ground clearance, requiring a height of tower of 78 ft. to top cross arm and 82 ft. over all. These towers themselves are of three weights, for straight line work, for spans up to 1500 ft. or angles up to 15 deg., and for use on dead ends and angles over 15 deg. The maximum size of conductor for which they are designed is 4/0 copper. At the present time, the one circuit is made up of 51 miles of 3/0 seven strand copper and 59 miles of 266,800 c/m 19 strand aluminum cable. The longest span is 4056 ft. at Greenhorn Gulch above Colfax.

The Cordelia sub-station located at the end of the Drum-Cordelia 110,000 volt transmission line was constructed in 1913 for the distribution of the 60,000 volt circuits of the Pacific Service.

DISCUSSION

F. H. VARNEY asked what velocity the water wheels developed in case they lost the load.

J. P. JOLLYMAN[1] said that the speed of these generators is 360 r.p.m. The velocity of that point on the bucket upon which

[1] Electrical Engineer Pacific Gas & Electric Co., San Francisco, Cal.

the center of the jet impinges is about 46 per cent of the velocity of the jet itself; and in the event of the loss of load other than friction (when of course the wheel will speed up) the speed will reach approximately 100 per cent over normal speed. That is about the limit of the overspeed that can be reached. It is probable that on a unit of this kind 90 per cent of overspeed would be the limit. As the speed goes up, there is a certain amount of interference between the buckets and the jets themselves. However, it was considered in the Drum plant that 100 per cent overspeed might possibly be reached, and the generator was designed so it might operate at this speed without any stresses exceeding the elastic limits, so that in the event of a runaway, no part would be deformed—an important consideration.

The generators were tested in the factory to double speed. That is something that is not always done, although the requirement is one that should be made and met to insure safe operation under all conditions. In some places, in order to take every precaution, this double speed test is made in a deep pit, and the machines are usually operated on a vertical shaft, and if they go to pieces they simply damage the sides of the pit. In the case of our machine, the builders (the Westinghouse Electric and Manufacturing Company) were so sure of their designs and workmanship that they tested the machine at double speed in a horizontal position above the floor.

When the machine is operated at excess speeds, the centrifugal forces become very high because at normal speed the peripheral velocity of the rotor is high, being in our case about 12,000 ft. per min. The centrifugal stresses are so high that it is difficult to maintain the rotor tight on the shaft, and cases have been known where rotors have loosened on the shaft at runaway speed. The hub of the rotor was bored .008 in. smaller than the shaft. Any less allowance might permit the rotor to loosen at double speed, and it is necessary therefore to have the rotors pressed on just as tightly as it is practical to handle them. The factory estimated that 750 to 1000 tons pressure would be required to force the rotor on the shaft, the fit being made in four steps of different diameters. In other words, of the total of about 44 in., the press would have to force the rotor ahead about a quarter of that distance. We thought it more expedient to heat the rotor and shrink it on, as this would avoid any damage to the shaft itself and any possibility of getting the rotor stuck, besides obviating the necessity for a press to give a thousand tons pressure.

The units in one of the Big Creek stations of the Pacific Light & Power Company are very similar to these units, in fact, they are almost identical, and I understand that in pressing the hubs in some of their shafts, this company had some little difficulty in handling the work. They had a very elaborate press, and took quite a long time to perform this work. As I remember, the third day from the time we started, the rotor was on the shaft. The entire water wheel with the buckets on was also heated in the same manner. These wheels could undoubtedly have been pressed on with a very moderate pressure, say, 200 tons, as the fit allowance was much smaller than the hub of the rotor.

The rotor is practically solid, and the object of this is twofold, to get the maximum strength, and to obtain the maximum amount of fly-wheel effect consistent with the amount of space occupied. In other words, we consider it a great advantage to get as much fly-wheel effect as possible without actually increasing the size of the machine. The fly-wheel effect of the rotor is about 1,750,000 sq. ft. and the stored energy is about 33,000,000 ft.-lb. or 1000 h.p. for a minute, and to bring the rotor from rest to full speed or stop it from full speed would require the application of 1000 h.p. for one minute. That is a considerable amount of stored energy.

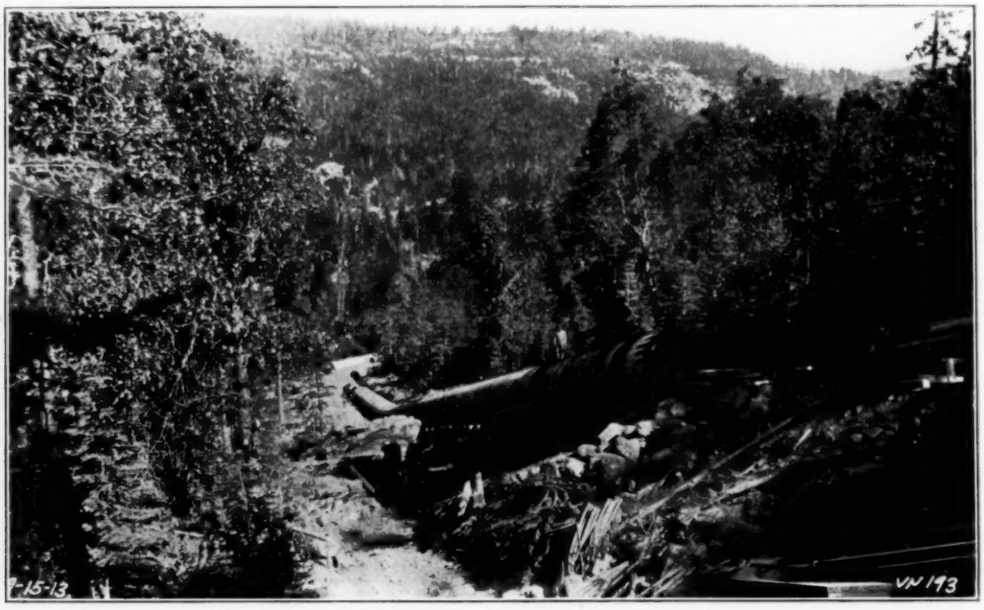


FIG. 7 CONSTRUCTION VIEW OF THE 96-INCH WOOD STAVE PIPE ON THE TAHOE SIPHON

In governing this plant, we are able to hold the speed within one-quarter cycle of the speed we term normal, and that is very close governing we think for so large a system. We have many fluctuating loads, although the fluctuations in the total load balance up to a remarkable extent; three or three and a half or four per cent is the maximum variation that we receive on the system as a whole. That may be 100 per cent on the governing machine or on the particular unit that is governing; but on the system as a whole three or four per cent from one minute to the other will cover the variations in load. The minimum load is roughly 40,000 kw., and the maximum load is 110,000, and this year it will probably reach 125,000. The variation from one hour to another is taken up by properly adjusting the loads on different units, but only one unit in one water wheel plant actually governs.

J. P. JOLLYMAN said that the essential requirements in the design of a bucket on an impulse wheel are that the water be turned and discharged at as low a velocity as possible so as to absorb the maximum energy, and that the bucket enter and leave the stream in somewhat the same manner that the teeth on a gear enter and leave those on a rack. As a tooth on a gear wheel rolls into one on a rack, the back of it must not interfere with the next tooth on the rack, and that principle must be observed in water-wheel practice. In other words, as the bucket gets into the moving stream the back of the bucket must not touch the water that is cut off by the face.

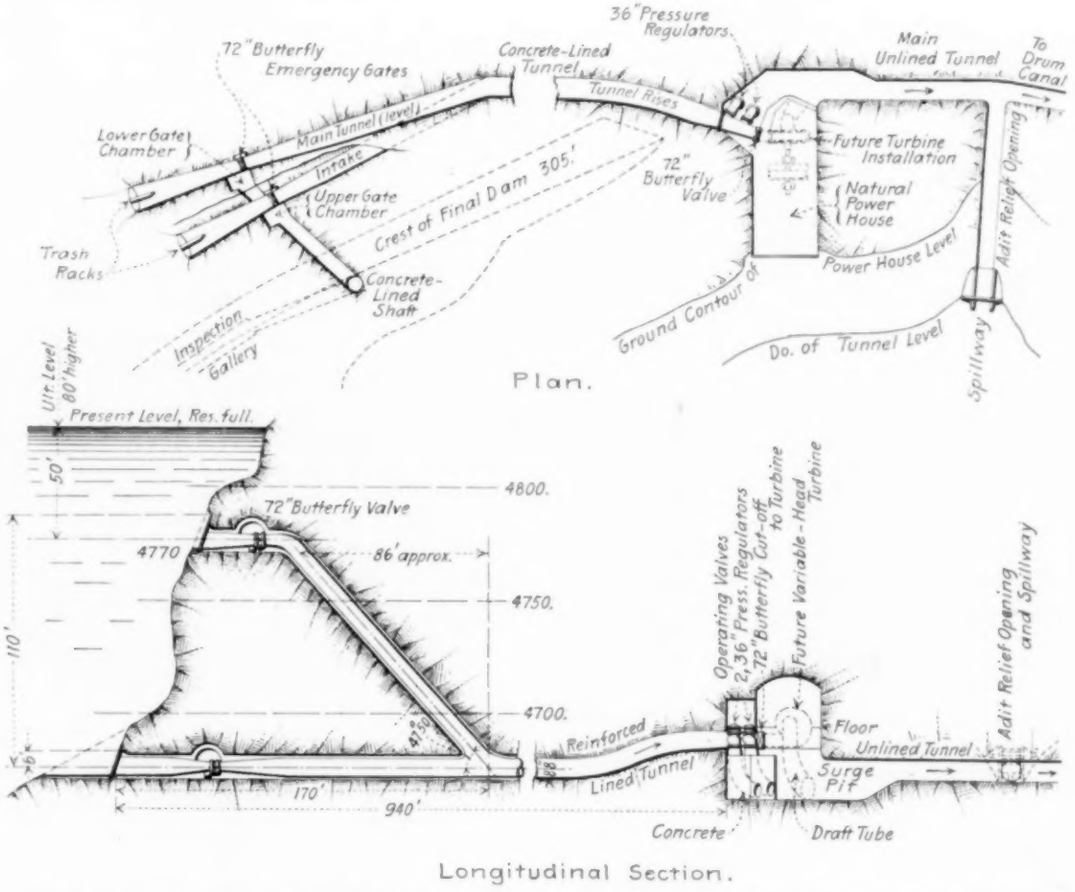


FIG. 8 DETAILS OF THE UPPER AND LOWER INTAKES AT THE SPAULDING DAM, SHOWING GATE CHAMBER

THOMAS MORRIN said that some three or four years ago several engineers called on W. R. Eckart, Sr., who had then practically finished the development of the face of the bucket and had turned his attention to the back. Mr. Eckart had found from a demonstrating apparatus that the bucket in use up to that time carried what we call in steamboat parlance, "dead water" on account of the form of the back of the bucket which offered a material resistance.

The principle of back design has been very much emphasized in the past few years. Mr. Eckart was one of the first to develop the idea and there are also others who have worked along these lines.

There are other requirements which of course must be met. The bucket must catch all of the water on the wheel. This limits the minimum number of buckets to probably 15. The Drum wheel has 17 buckets. If you have less than 15 buckets, all the water will not be caught.

The attaching of the buckets to the disc is also an item of very considerable importance, in view of the manner in which the stresses on the attachment vary. If the bucket is running free from the jet, it is acted upon by centrifugal forces only, which tend to throw it off the wheel. When

struck by the jet, the bucket is acted upon by a combination of tangential and centrifugal stresses, which may cause a reversal of stress on some of the attaching bolts. The reversing stress is naturally very hard to take care of, being a hammering effect first in one direction and then in the other. Reversing stress has caused a good deal of trouble in some of the wheels where the design of the attachment has not been properly worked out.

F. H. VARNEY said that he understood that at different times more or less trouble was experienced in plants such as described from erosion and sand-blast action and so forth. He asked Mr. Jollyman what had been done in the Drum to overcome that action, and also what classes of metal are now used for the water wheels, what metal the buckets and discs are made of and what metal the buckets are held on with.

J. P. JOLLYMAN answered that in some of the older designs of water wheels, corrosion which has the appearance of sand-blast action or pitting has taken place usually at the bottom of the lip of the bucket where it first cuts into the jet, and the buckets have been honeycombed and eaten away. It was thought for a considerable time that this was due to sand in the water; but the same action took place in some cases where there was no sand. Where the water came from settling reservoirs and was positively clear, the same erosion was found in some cases. Then it was thought that possibly air in the water, being liberated at this point, was causing the erosion. The principal cause was finally decided to be improper design. If there is interference between the back of the bucket and the jet, in other words, if the back of the bucket presses against the jet instead of keeping away from it or if in the course of the bucket's path through the jet, pressure is put on a point and then released suddenly, pitting will take place. I believe that most engineers now concede that pitting can be very largely avoided by so designing the parts, that the water will be deflected uniformly, and no very sudden change in the direction or rate of motion of the water allowed to take place and that there should not be any interference between the back of the bucket and the jet. With those precautions observed, there seems to be very little honeycombing, pitting or wearing.

A certain amount of wear on the face of the bucket is unavoidable, but with buckets of good design this wear is very small. We have had wheels at DeSabla operating under 1531 ft. head (that at Drum is 1375 ft.) for eleven years and they do not show very much wear. The original buckets are still on the wheels and have been used almost constantly. Those buckets and the buckets on the Drum wheel are cast steel. At one time it was thought that buckets of bronze would wear better than buckets of cast steel, but I do not believe that the material is as important as the design. The pitting is more easily and more correctly explained by incorrect design than by chemical action or the material. In places where a large amount of sand is carried by the water, I think it is probable that bronze has a slight advantage over cast steel. The bronze seems to have something of the effect of rubber which is very slightly eaten away by sand-blast as compared with a piece of steel. Bronze seems to have a certain yield or tendency to hold together that cast steel does not have.

F. H. VARNEY asked whether vanadium steel had been used.

J. P. JOLLYMAN said that he did not believe so. He thinks the buckets are cast from open hearth steel. The wheel centers on the Drum machines are cast steel. They had some wheel centers made of steel similar to that used in armor plate; but they believe now, with the increased knowledge of what may be done in the way of attachment, that it is not necessary to have a steel harder than nickel steel or good open hearth steel for these conditions. For very much higher heads than occur in present practice other steel may be necessary.

WM. J. DAVIS, JR., asked how the speed regulation governors of the Drum Power House are set.

J. P. JOLLYMAN answered that the drop in speed from no load to full load on the governors is adjustable. With one unit governing the system they adjust that for zero drop in speed. In other words, the unit tends to maintain a uniform speed at any load. Of course if more than one unit is required to govern, then both must be given a small drop in speed, about one or two per cent, in order to let them operate in parallel and both govern. As a matter of fact the Drum units are of sufficient capacity to govern alone; and with one unit governing we set the governor so it gives the same speed at full load as it does at normal. The whole system is then governed.

WM. J. DAVIS, JR., asked what is the effect of the setting of the governors on the parallel operation of the Drum Power House with the steam plant in San Francisco. He thought it would be desirable to have the steam plant take the fluctuations of load, and the water plant a constant load.

J. P. JOLLYMAN said that would be the best arrangement for operation. The fact is that the transformer capacity between the hydro-electric system and the steam plant is limited and it is hardly possible to let the steam govern the whole system for fear of overloading the transformers. The San Francisco steam plant has a capacity of 40,000 kw. The transformer capacity between the hydro-electric and the steam is only 9000 kw. They do not attempt to carry the whole of the San Francisco load from transmitted power. In fact their system at the present time of the year could not do that. It is rather the better condition to govern by steam and use all the water. As a matter of fact, to do that would throw fluctuations into this plant of greater amount than its present capacity. With a zero drop in speed for changing load, the Drum governing machine tends to take all the fluctuations out of the system; and the operators of the steam station have to watch the loads on the connecting cables very closely to assist in the governing, to prevent the overloading of these cables.

The parallel operation of the system as a whole is very satisfactory indeed, there being no reciprocating units used but only rotating machines. The steam turbines and the water wheels are all of uniform rotating speed. There is no surging between one unit and another and no tendency to drop out of step.

RECENT DEVELOPMENTS IN STEAM-ELECTRIC GENERATING STATIONS

BY JOHN HUNTER, ST. LOUIS, MO.

Member of the Society

THE meeting of the St. Louis Local Section on October 28, 1914 was a joint meeting of the Associated Engineering Societies of St. Louis, held under the auspices of the St. Louis Section of the Am. Soc. M.E. at which an address was delivered by John Hunter, chief engineer of power plants of the Union Electric Light and Power Company of St. Louis, Mo. Mr. Hunter summarized the equipment of the large generating stations in New York, Boston, Philadelphia, Washington, Detroit, Chicago, Milwaukee and St. Louis, and traced in an interesting manner the phenomenal development in power generation as exemplified in these plants. Some extracts from the address are given herewith, as abstracted from a report of the meeting that appeared in Power, December 22, 1914.

At present there are 15 different public-service corporations supplying power to the five boroughs of the city of New York. The New York Edison Co., operating the great Waterside stations, dates back almost to the beginning of the electric-light industry. The old Pearl Street Station, the first Edison electric-lighting station in New York, was built in 1882. Up to the advent of high voltage, alternating-current transmission and distribution, there were numerous steam stations of the non-condensing type for direct-current generation built here and there about Manhattan Island. The first plant of any considerable size was Waterside station No. 1, built in 1900 and designed for sixteen 3500-kw. alternating-current generators driven by vertical compound engines. In 1905, after eleven of these units had been put in, the equipment was completed by the addition of three 5000-kw. vertical turbines and two 10,000-kw. horizontal turbines. In 1911 and 1912 four of the engine units were removed and three 20,000-kw. vertical General Electric turbine units installed. At the same time one of the 5000-kw. turbines was rewound for 9000 kw. The total capacity of the plant is thus 123,500 kw.

This station was rapidly outgrown and Waterside station No. 2 was built in 1909. It adjoins the No. 1 station and together, so far as operation is concerned, they are practically a single station and form the largest steam plant in the world, having a combined capacity of about 215,000 kw. The No. 2 boiler house contains ninety-six 650-hp. Babcock & Wilcox boilers operating at 200 lb. pressure with 125 deg. superheat. The boilers are in eight rows across the boiler house, six in a row and on two decks.

In the turbine room there are six 8000-kw. Curtis turbines, two 8000-kw. Westinghouse turbines and two 14,000-kw. Curtis turbines. Each of the Westinghouse turbines drives a twin generator, one 25-cycle, 6600-volt, and the other 60-cycle, 7500-volt. Either is used as required; they run at 750 r.p.m. The main generating units are equipped with surface condensers, utilizing salt water from the East River for cooling. To provide against a shortage of coal in case of strike or delayed deliveries, the company has a storage yard at Shadyside, on the New Jersey shore, capable of stocking 200,000 tons.

The Fifty-ninth Street station of the Interborough Rapid Transit Co., which carries the subway load, is of special interest in that it has five of the largest exhaust-steam turbines in existence. The original installation was completed about 1903 and contained nine 700-kw. Allis-Chalmers (combined double horizontal and vertical, 11,000-volt, 25-cycle). Later, about 1905, three 1725-kw. Westinghouse turbines were installed. Each of these engines had two horizontal high pressure cylinders 44 in. diameter and two vertical low pressure cylinders 88 in. diameter, with a common stroke of 60 in. The original boiler installation was fifty-two 600-hp. Babcock & Wilcox water-tube boilers, with space for 20 additional boilers; eight more were eventually put in.

Due to the rapid increase in the demand for electric current from this company, the capacity of the station had to be increased. Five low-pressure Curtis turbines of 7500-kw. capacity were installed between and to one side of the reciprocating engines without purchasing additional real estate. The method used in starting up the combined engine generator and low-pressure turbine is simple. Excitation is applied before starting, then, when brought up to speed, the machine is synchronized in the usual manner. While starting in this way, the induction generator connected to the low-pressure turbine acts as a motor until sufficient steam passes through the engine to carry the turbine above synchronous speed, when it immediately becomes a generator and picks up the load. The leads of the turbine are tied in solidly to the main generator leads through knife switches which are never opened.

The net results obtained by the installation of the low-pressure turbines in this station have been summarized as follows:

An increase of 100 per cent in the maximum rating of the plant.

An increase of 146 per cent in the economic output of the plant.

A saving of approximately 85 per cent of the exhaust steam for return to the boiler.

An average improvement in economy of 13 per cent over the best high-pressure turbine results.

An average improvement in economy of 25 per cent (between the limits of 7000 kw. and 15,000 kw.) over the results obtained by the engine units alone.

An average unit thermal efficiency between the limits of 6500 and 15,000 kw. of 20.6 per cent.

In the Seventy-fourth Street station of the Interborough Rapid Transit Company, there are 64 Babcock & Wilcox boilers and the generating equipment comprises eight Allis-Chalmers 7500-kw. combined horizontal and vertical Corliss engines, similar in all respects to the original installation in the Fifty-ninth Street station, and one 7500-kw. Westinghouse horizontal turbine of the same rating as the engines.

Abstract of paper presented at the St. Louis local meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on October 28, 1914

The growth of this company's business again required additional capacity from its generating stations and it has now decided to remove four of the engine units and install three Westinghouse turbines, each of 30,000-kw. capacity. These turbines are cross-compound units. The high pressure element is a single-flow turbine operating between steam-boiler and approximately atmospheric pressure. On leaving the high-pressure cylinder, the steam goes through a receiver separator and then into the double-flow, low-pressure cylinder. The high-pressure end operates at 1500 r.p.m. and the low-pressure expansion end at 750 r.p.m.; both ends are controlled by a single governor driven from the high-pressure spindle. The two generators are electrically tied together, therefore no governor is needed on the low-pressure end. The guaranteed water rate is 11.27 lb. per kw.-hr. Steam enters the center of the turbine through two openings and then divides, one half going each way to a condenser at each end.

The Philadelphia Electric Co. has two main generating plants, stations A-1 and A-2. Station A-1 is equipped with turbines varying in size from 750 kw. to 15,000 kw. For this station a 35,000-kw. General Electric turbine is now being built. While it is 5000 kw. larger in capacity than the large Westinghouse cross-compound turbine, it is contained in one unit and involves special characteristics recently developed by the General Electric Co. To permit of greater mechanical stability and to provide greater area in the low-pressure end, the casing is divided into two parts with a bearing between. The revolving field is an enormous steel forging, with milled slots, similar to small machines. The armature frame is cast in two halves, each of which represents about the limit of casting and transportation possibilities. The turbine and generator are mounted on a common base, thus constituting a single generating unit, in this respect surpassing anything else heretofore attempted.

Delray plants Nos. 1 and 2 of the Detroit Edison Co. are four miles southwest of the business center of Detroit, on the banks of the Detroit River. No. 1 station, built in 1904 and containing four 3000 kw. units, now has four 8000-kw. Curtis turbines. No. 2 station, built in 1908, has three 14,000-kw. and one 15,000-kw. turbines, making the turbine rating of the two plants 89,000 kw.

The original design of the No. 1 plant included a surplus of boiler capacity for the purpose of permitting the four original 3000-kw. Curtis turbine sets to operate noncondensing; the exhaust steam was to be supplied to salt refiners in the vicinity for evaporating brine. Twenty-four 500-hp. Stirling water-tube boilers were installed, set in four batteries of six each. Each boiler contains 4834 sq. ft. of heating surface. The second bank of tubes forms the superheater with an area of 1500 sq. ft. and superheating to 600 deg. fahr., or 200 deg. fahr. above the normal temperature of the steam at 210 lb. per sq. in.

The first four turbines in station No. 1 were run condensing. The plan for supplying exhaust steam to the salt refiners was never carried out because the company's load had so increased that it was found necessary to install an additional 3000-kw. unit; this was done without increasing the boiler equipment. The first four 3000-kw. machines of 1904 were replaced in 1911 by 8000-kw. units of similar type, equipped with Worthington 16,000-sq. ft. surface condensers of the base type.

The No. 2 turbine room has three 14,000-kw. and one 15,000-kw. vertical Curtis-General Electric turbine units, which, like the machines in No. 1 turbine room, furnish 4600-volt, 60-cycle, three-phase energy. The turbines are ventilated by forced draft and the dampers are so arranged that air can be taken from the engine room and delivered to the outside, or, as is desirable in winter, the outside air can be taken into the machines and delivered to the engine room.

Of special interest in connection with the Delray plants are nine big double-fired Stirling boilers in the No. 2 power house, each having a rated capacity of 2365 hp. The normal output is 7000 kw. in regular service and they have been drawn upon for 11,000 kw. during short periods. All are equipped with Taylor stokers, which have a nominal area of 300 sq. ft., with a heating-grate ratio of 79 to 1. The steam pressure carried in this plant is 205 lb., with a 150 deg. superheat. This is one of the first stations to develop high superheat. The original steam fittings were cast iron and had to be changed to steel after five years, weakness in the iron having developed. The superheaters are mounted between the boiler tubes proper.

Each of the 54-in. steam drums has eight 4½-in. safety valves besides four 3-in. valves on the superheaters. The advantages in the use of these large units are found in a decreased cost per horse power of rating; a lower radiation loss per unit of capacity, hence a higher efficiency, and they occupy smaller area per unit of output. Repairs on these large units are not excessive and do not exceed the usual cost per horse power with small-size units. The combined boiler and furnace efficiencies obtained run from 80 per cent at 75 per cent rating to 76 per cent at 200 per cent.

With the city's phenomenal growth in demand for electric energy, the Detroit Company has under construction a 100,000-kw. plant at Connor's Creek, which is at the opposite end of the city near Lake St. Clair. This plant is expected to be completed to take the fall load of 1915.

By far the greater part of the electrical energy generated by the Commonwealth Edison Co., in Chicago, is produced at the Fisk Street and Quarry Street stations, which are on the south branch of the Chicago River. The engine room of the Fisk Street plant is 630 ft. long and was originally designed for fourteen 5000-kw. vertical Curtis turbine units. The first unit was installed in 1903, but later it was decided to use 12,000-kw. units instead of 5000. One of the 12,000-kw. units had been installed when the advance in the art led the company officials to decide that the last four units should be of 20,000-kw. capacity, or larger, and of a horizontal type. Of these two are already installed, one a General Electric 20,000-kw. and the other a Parsons 25,000-kw. turbine.

The boiler house of the Fisk Street station was originally designed for fourteen batteries of eight 500-hp. boilers, and ten of these batteries, comprising eighty boilers, are already in use. The remainder of the boiler house will be filled with four batteries, each of four boilers and each boiler having 12,250 sq. ft. of heating surface, with an equipment of economizers and induced draft fans with which, it is anticipated, the boilers can be worked at 200 per cent of rating. The combined generating capacity of all the units at Fisk Street is 165,000 kw. When running at full capacity the station will consume nearly 2000 tons of coal a day, and nearly 200 tons during the maximum or peak hour. The number of heat units required to generate a kilowatt-hour with the old equipment was approximately 28,000; with the new equipment it is something less than 20,000. This would be 2 lb. of coal at 10,000 B.t.u. or 1.43 lb. at 14,000 B.t.u.

The great increase in the business of the Commonwealth

Edison Co. made it necessary to build the Quarry Street station in 1908. The two stations are operated together as one electrical generating station, being connected by tie lines in two tunnels.

Arranged in two rows parallel to the turbine room are eight 500-hp. water-tube boilers for each generating unit, or 48 for the entire station. The original boiler setting at Quarry Street was a departure in furnace design in that the furnaces were placed under what is usually considered the rear header. In other words, the slope of the tubes was up and away from the furnace rather than the reverse. The advantage sought was in the long combustion chamber, expanding in volume, which made for more complete combustion of the fuel and an increase in boiler efficiency. These boilers were equipped with horizontal passes. After a time it was found that the maintenance costs were running high, and it was decided to equip the last six of the boilers with standard settings, although at the same height as the other; this gave a larger combustion chamber than is the usual practice. Eight boilers are independently connected to each of the six turbines, although cross connections are available in case of emergency. Quarry Street was the first station in the United States to install centrifugal boiler feed pumps.

The rate at which the business of the Commonwealth Edison Co. was increasing made it evident in 1910 that the Fisk and Quarry Street stations would be inadequate for the service and plans were immediately made for additional station equipment. The new Northwest Station has been the result. Between 1908 and 1910 the maximum load of the system grew from 117,370 kw. to 182,600 kw., an increase of 55½ per cent. In 1912 the maximum load had further increased to 200,000 kw. In planning for the capacity of the new station the indications were that for a number of years the increase would average at the rate of 15 per cent per year. This rate of increase, applied to the load of 200,000 kw. in 1912, indicated that the net increase of load during the following five-year period would amount of 220,000 kw.

Accordingly, plans were made for two new power houses of 220,000 kw. each, it being considered advisable to prepare for more than five years' growth. A location was therefore selected which would be suited to the many and great requirements of such an equipment. To supply fuel for an aggregate of 240,000 kw., or 350,000 hp., requires something like 4000 tons of coal per day, or 100 car loads. Inasmuch as the fuel has to be brought 200 miles by rail for the Chicago plants, a reserve supply of even four days, if held in cars, would mean four miles of track room for 400 cars. The coal strikes, which occur quite regularly every two years, however, frequently mean that no coal can be had from the mines for three months. Hence one of the demands of the new plant was that there must be sufficient storage for coal to carry the stations over a three months' interval—that is, storage room for 350,000 tons. The site of the new Northwest station was therefore chosen at a point on the north branch of the Chicago River, several miles from the Fisk and Quarry Street stations, where sufficient acreage for coal storage was available.

The boiler house is so designed and equipped that at no point in the handling of the great volumes of coal that daily passes through it, is it necessary to use manual labor. The boilers are arranged in rows of ten each, facing each other on opposite sides of a common firing aisle, so that one set of firemen and water tenders can look after twenty boilers. Each ten boilers are served by a tile-lined steel stack, 17 ft. inside diameter and extending 275 ft. above the boiler-room floor. When completed the turbine room will be 290 ft. long with the five turbines spaced on 44-ft. centers. The first two turbines are of the vertical Curtis type, similar to those of the Fisk and Quarry Street stations, and are rated at 20,000-kw. capacity, with a steam consumption of 13.45 lb. per kw.-hr. at the most efficient load, namely, 15,000 kw. The additional units for this plant are expected to be of the horizontal type and may run in capacity to 30,000 kw. or more.

TECHNICAL DISCUSSION

COMMUNICATIONS UPON ENGINEERING SUBJECTS TREATED IN PREVIOUS ISSUES OF THE JOURNAL

A RATE-FLOW METER

J. W. LEDOUX, in a written discussion on the paper by H. C. Hayes on A Rate-Flow Meter which was published in abstract form in the March issue of The Journal, said that the question of using the difference in pressure at the inner and outer diameter of a pipe bent to a curve has been considered by engineers for a considerable time past, but this paper, for the first time to the writer's knowledge, gives a rational discussion of the elements affecting the flow under these conditions.

Any form of meter of this kind, of course, depends on the true bore of the pipe. As a casting is always subject to considerable variation, machining is resorted to in all first-class forms of Venturi tubes. For Pitot tube measurements, resort is had to traverses and measurement of the diameter of the pipe in place. With the Venturi tube the coefficient of discharge is determined by experiment for a considerable number of sizes, so that the accuracy attainable at the present state of the art for ordinary velocities can be counted on with probably 1½ per cent. With Pitot tube measurements, the calibration of the Pitot tube itself is carefully determined by experiment in the same way, so that when the traverse of the pipe is once made, the results with a Pitot tube in the center of the pipe can be counted on for all mean velocities within the range of the apparatus, say from half a foot per second up to ten or more ft.

The simple formula for the flow in an inferential meter of any of these types including that described by Mr. Hayes is

$$H = c\ v^n$$

in which

v is the velocity through the pipe or meter.
c is a constant coefficient.
H is the head.

For any form of Venturi tube, orifice, or Pitot tube, n becomes 2 and when c is once determined by calibration, it is used without change for all meters of the same class.

For the V notch weir n becomes 2/5.

For the rectangular weir about 2/3.

For Mr. Hayes' device n appears to be 2.2, but the question is whether, if his experiments were sufficiently extended, this value of n would not approximate 2. If this exponent cannot be counted upon as a constant under various conditions and sizes of vortex meters, the ap-

paratus cannot be considered satisfactory as a commercial proposition.

At first sight, it would seem that the large deflections for given velocities as compared with the other two devices would be an immense advantage, and that is true providing we had to do with mean velocities below 1 foot per second only, but the ordinary Venturi or Pitot tube meter is often required to give its greatest accuracy at velocities considerably above 1 foot per second, and for a Venturi tube with a ratio of two to one, the deflection for only 6 ft. mean velocity corresponds to about 10 ft. of water head, or say 10 in. of mercury head, and a meter requiring much more than this becomes cumbersome in size.

Mr. Hayes states in his Par. 17 that "Such a meter should not be greatly affected by fluctuations of pressure such as are always produced by feed water pumps, for the inertia of the vortical mass will serve to steady the gauge readings much as the fly-wheel does the motion of an engine." If that is the case then it is only necessary to use on the small pipes leading from any form of meter to the register, some inertia device of sufficiently large mass of heavier or lighter liquid than that to be measured, but there is a prevailing impression that any form of inferential meter, including the one under consideration, will not measure accurately if there is a violent fluctuation in rate of discharge, a condition that is frequently caused, for example, by a reciprocating pump, which is not connected with a large air chamber. If that is true, the defect obviously cannot be remedied unless the vortical mass can in some manner induce a uniform rate of discharge through the pump. This subject, however, has not been fully investigated.

The heretofore objections to metering water with these inferential types have not been due to the shortcomings of the Venturi tube but to the limitations of the registering devices. Mr. Hayes refers to several well-known devices, some of which depend on cams and others on the movement of shaped floats, and he concludes that the trouble with these devices is the necessity of a stuffing box which introduces so much friction as to interfere materially with the accuracy. The stuffing box, however, is the least of the difficulties, and with well-designed details, the results are approximately as good with the stuffing box as without, because the shaft connecting the inside and outside of the meter register is so small compared with the radius of the rack-pinion or sheave, that this friction is negligible. Any form of cam, however, introduces another kind of an error that is much more serious. Mr. Hayes would overcome all these objections by using the device shown in his Fig. 7 of the March issue of The Journal and of Fig. 16 of his original paper. This principle was investigated by the writer as far back as 1904, after which it was found that Mr. Walter Ferris was really entitled to the priority of invention, although while illustrating the basic principle his disclosure did not show it in a very practical form for commercial use.

According to Mr. Hayes' presentation, the radius of the shaped vessel becomes infinite before the flow has reached zero, and therefore, this particular type of meter has a serious theoretical limitation, which makes it incapable of measuring with the same instrument from the highest to the lowest flows. In fact, it has the same limitations as the type using the parabolic cam, which is vertical to its axis at the minimum velocities.

The flexible tube introduces a very objectionable feature except where there is no pressure in the vessel, when it can be made of rubber tubing with thin walls, but the weight of the mercury in the cylindrical vessel must be externally resisted by some form of contrivance that operates in such a manner that the resistance is proportional to the weight. This means a spring, or a weight with a variable lever arm, or some other equivalent device. Every one who has had to do with springs knows how difficult it is to get them to act according to their theoretical law and retain their properties for any great length of time. Presumably Mr. Hayes would make vessel B of glass and have attached thereto a uniformly graduated scale, which would give true indications of the heights of mercury in terms of velocity within the theoretical range of the instrument.

The apparatus described for eliminating the effect due to temperature is ingenious but probably impracticable for commercial cases, and at any rate, the differences due to changes of temperature are not important in water measurements, because the errors due to the ordinary range of temperatures can be neglected, and where the meter is used for hot water, it can be adjusted for the desired temperature by simply changing the size of the pinion or sheave.

There are a number of ingenious and practical registering devices of great merit in experimental use that have never as yet to the writer's knowledge been publicly described or illustrated, and this is the line of investigation that seems to warrant the expenditure of inventive effort.

In passing, it would seem that Mr. Hayes did not write his article with the idea of having it easily understood by the practical man, familiar with ordinary mathematical processes. The writer has not checked up the mathematical results because it would seem that those with which he is already familiar are more simple and direct. It is always desirable to simplify such discussions so as to be within easy reach of the maximum number of investigators.

On the whole, the writer believes that Mr. Hayes deserves great credit for his effort and accomplishment.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

One of the unfortunate results of the present events in Europe is the fact that many of the engineering societies there have been forced to abandon their usual spring meetings at which valuable papers were formerly presented.

THIS MONTH'S ARTICLES

In the section on Air Engineering is abstracted a discussion of the advantages and disadvantages of various blowers for cupola service, in which, among other things, the author questions the wisdom of using a single blower for several cupolas of different sizes.

The economy and possibilities of the use of Diesel engines for ship propulsion is discussed, both generally and with reference to data collected by actual experience. The author apparently believes that while a Diesel engine is somewhat more economical than a steam engine, its economy, in view of some other disadvantages, is not sufficiently high to carry with it the promise of materially displacing the steam engine as a prime mover on the high seas.

An abstract of the article on ball-bearings in electric railway cars in Switzerland shows an interesting design of ball-bearing installation, especially on center bearing between the underframe and bogie of the cars.

Two articles are devoted to the subject of boiler explosions. One describes an explosion of a locomobile boiler and shows how an apparently good boiler may become exceedingly dangerous because of presenting possibilities of improper manipulation. The other article shows that boiler furnaces fed with lignite coal, rich in gas, may, under certain circumstances, act somewhat as a gas producer and lead to disastrous explosions.

The article on German progress in steam boiler firing, the beginning of which was abstracted in *The Journal* for March 1915, is continued in abstract in the present issue.

An interesting account of tests on inclined cables is abstracted from the Journal of the Engineers' Society of Pennsylvania. W. H. Phillips, in a paper before the Engineers' Society of Western Pennsylvania, gives some data on a new secret method of heat treatment of gears called the B. P. Process, as well as on heat treatment of railway gearing generally. This paper led to an interesting discussion partly abstracted in the section Engineering Societies. J. D. Berg describes a low pressure steam turbine installation for mill drive, of particular interest both on account of its engineering features and also because it is the only one of that kind in existence in this country and the second installed anywhere.

Alan E. L. Chorlton, in a paper before the Institution of Mechanical Engineers, discusses the question of convertible gas engines and shows the kinds of engines, and conditions, which particularly lend themselves to use with more than one type of fuel. Among other things, the paper describes the Clerk supercompression engine.

Particular attention is called to the paper by Charles H. Lees (Royal Society) on the Flow of Viscous Fluids Through Smooth Circular Pipes, which contains not only interesting formulae but also presents a valuable discussion of the work previously done on this subject.

FOREIGN REVIEW

Air Machinery

ADVANTAGES AND DISADVANTAGES OF VARIOUS TYPES OF BLOWERS FOR CUPOLA WORK.

The article discusses the advantages and disadvantages for cupola service of various types of blowers, centrifugal, rotary, and reciprocating.

The output of centrifugal blowers or fans is dependent upon a definite cross-section of outflow at which they can attain their highest efficiency. If, at the same speed of rotation, the most favorable cross-section of outflow is changed, both the amount of air taken in and that delivered by the centrifugal blower change in accordance with a known law. These changes are considered by the builders of centrifugal blowers and by some foundrymen as an advantage, but there appears to be a prevalence of opinion that really they are disadvantageous because they oppose in an undesirable manner the changing resistances in the cupola.

In regard to rotary blowers (of the Root and similar types) their action in delivering a practically constant amount of air under all conditions, appears to work favorably together with the change of resistances in the cupola.

Previous investigations have shown that as far as the operation of the cupola is concerned, the amount of air delivered and the air pressure are the determining magnitudes for the blower. It would have been of considerable interest, therefore, to find out whether and in how far standardization of cupola blowers is desirable.

In regard to the measurement of air delivery in the case of cupola blowers, many tests have established that anemometers give indications which are too large, and measuring nozzles, indications which are too small. The measurement of air on the basis of pressure differences in a double nozzle does not seem to have been as yet widely introduced in cupola service. Air may also be measured by exhaust gas analysis, but that is hardly suitable for small foundries. The measurement of air pressure as done now does not satisfy even the desire for information as to whether the required amount of air goes through the cupola, but, as soon as we start to measure the air in the state of motion, there will be a greater impetus for more thorough regulation of cupola blowers which can now be effected in a number of ways, for example, by varying the speed of rotation, or cross-section of outflow (of blower or piping).

As regards regulation, centrifugal blowers seem to have an advantage over rotary blowers because the power consumption in the former is within certain limits nearly proportional to the air output. On the other hand, the centrifugal blowers have a disadvantage in that, especially when driven by belting or other indirect transmission, they admit of only a limited variation in the speed of rotation and a certain excess of air has to be wasted by blowing off, which represents a corresponding loss of power and money. We have very little or no information as to the magnitude of

the losses which occur in that or another type of cupola blower as a result of the regulation of air output, which is indirectly proved by the fact that often several cupolas of very different dimensions are served by one blower.

It may be possible that if the losses due to regulation were better known, it would have been found that in the end it pays better to provide each cupola with a separate blower suited to its dimensions; if this were done, there would be a strong argument in favor of centrifugal blowers because of their low space and foundation requirements, ease of location in close proximity to the cupola and their practically noiseless operation.

It must be borne in mind that in a cupola operation it was found to be of great advantage to work with as uniform an air pressure as possible; this is one of the characteristics of centrifugal blowers and makes unnecessary the installation of equalizing air tanks on the cupola, or collectors in the piping. The author believes that in the selection of a suitable blower it would be well, before making a decision, to answer the following questions:

1. Are the variable resistances opposed to the blast in the cupola, such as clogging of the nozzles, hard and loose formation of bed of the charge, variable heights of charge, etc., so well determined in practice that their influence justifies the preference for a rotary blower?
2. Are the losses in power caused through regulation, often amounting to from 30 to 50 per cent of the normal air output, so low that one can operate for years two ovens with one blower large enough to fulfill the requirements of the larger oven, without suffering great losses?
3. Do differences in efficiency and first cost constitute a basis for preferring one or another type of blower, or must the influence of internal resistances in the cupola be also taken into consideration?
4. How can we, in the most certain manner, determine the amount of air passing through the oven and the power usefully required for operating the cupola blower?

(*Vor- und Nachteile verschiedener Gebläsearten für Kupolöfen,* J. Treuheit, *Stahl und Eisen,* vol. 35, no. 4, p. 102, January 28, 1915, 2 pp., *p*).

Internal Combustion Engineering

LARGE DIESEL ENGINED SHIPS FOR MARINE NAVIGATION AND THEIR ECONOMIC POSSIBILITIES.

The article discusses the economy and possibilities in the use of Diesel engines for ship propulsion.

During the last three years, about fifty sea-going vessels have been either built or laid with Diesel engines as the propelling machinery. Nevertheless, engineers and shipbuilders are as yet by no means agreed as to the economy of this method of propulsion. At first sight, shipbuilders have been strongly influenced by the difference between the thermal efficiency of a triple expansion steam engine amounting to about 14 per cent, and the 38 to 40 per cent claimed for the Diesel engine. In addition to that, three years ago, at the time when the Diesel patents ran out, the prices of crude oil were very low and in this respect the entire proposition looked far more attractive than it does with the present prices of oil, nearly three times as high.

The question of economy of Diesel engined ships has to be considered in the first instance in connection with the kind of fuel for these engines. The main source of the fuel is the Atlantic Coast of the United States, Pennsylvania, Ohio, Texas and the southern states. There are large supplies of oil in Mexico around Tuxpan, but Mexican oil is not very well suited for use in Diesel engines, particularly because of its high asphaltum and sulphur contents. California oil, while available at present, will probably advance considerably in price after the opening of the Panama Canal, and in addition to that, a combination of powerful European interests have lately obtained control of a production of from 300,000 to 400,000 tons of oil per year. As far as sea navigation is concerned, the Russian, Roumanian and Galician oils are not as yet of much importance, especially as the Russian oil is said to be unsuitable for Diesel engines. In eastern Asia, however, large supplies of oil of the Diesel engine quality are available.

Rieppel has found in his investigations on Liquid Fuels Suitable for Diesel Engines that the most convenient are high percentage gas oils and paraffin, but the tar oils and hydrocarbons with a heating value below 9,000 WE (16200 B.t.u. per lb.) and containing asphaltum cannot be directly used in Diesel engines. Of late, however, it has been found that oils with an asphaltum content not in excess of 26 per cent and sulphur content not in excess of 2 per cent and a state of fluidity at 4 deg. cent. can be used in Diesel engines provided they are free from water, mechanical impurities and give no material ash residue. As a rule, crude oil is only in the rarest cases directly suitable and clean enough for use in Diesel engines. It is usually the products of distillation, distilled from temperatures between 150 and 350 deg. cent. (302 to 662 deg. fahr.) that can be used in an engine provided their asphaltum and sulphur contents are not excessive. Distillates of lignite coal tar, obtained particularly by dry distillation of tar, are very convenient for use in Diesel engines. Owing to their high contents of paraffin, these oils, when injected into the working cylinder at a temperature corresponding to a compression pressure of from 33 to 34 atmospheres, form an oil gas which ignites with extraordinary facility. Coal tar, however, because of its low hydrogen content can be burned in a Diesel motor only with considerably more difficulty, and to help that, to the coal tar from 5 to 10 per cent kerosene is added, or the oil is preheated. For sea navigation outside of Germany, coal tar has, however, little importance.

So much for the source of fuel; now as regards the economy and efficiency of Diesel engines as compared with a steam plant of the triple expansion type the following data may be of interest: They refer to two vessels, the Saltburn and the Eavestone, both of the Furness Line. Both are comparatively small vessels of equal length, beam, free board and depth. The weight and machinery is in the case of the steamer 1280 tons (metric) and the motor ship 1260 tons. The carrying capacity for the same water line is in the steamer 3080 and the motor ship 3100 tons. Excess of loading room in the case of the motor ship as compared with the steamer, 190 cbm. (6700 cu. ft.). Both ships were sent on the same trip. The steamer traveled at a speed of 8.7 knots and consumed 12 tons of coal per 24 hr. The Diesel engine vessel went with a speed of 8.66 knots and an oil consumption of 3.95 tons per 24 hr. This shows a ratio of oil consumption to coal consumption with the consumption of the auxiliary boiler used to drive the rudder engine taken into consideration, to be 1:2.88, and that shows that the ratio often in-

dicated in theoretical works of one ton of oil to four or five tons of coal is not confirmed by actual practical experience.

Table 1 shows what the situation would be if, in addition to the pure fuel consumption of both engines, we compared also the expense in lubricants, depreciation and wages. The data reported there are taken from actual experience and comparison between the Diesel engine ship Christian X, equipped with two single acting four-stroke cycle 8 cylinder engines and the steamer Uckermark equipped with a modern superheated steam plant. The increased wages on the Diesel engine ship were due not so much to the difficulty of finding proper men to manage these ships but to the constant complaints of the men with respect to the strict service which they have to maintain, the large number of repairs and installation work, as well as the excessive attention which the power plant requires from the engineer. Of particular interest in an investigation of the efficiency of Diesel engine

TABLE 1 MAIN COMPARATIVE DATA OF A STEAMER (S) AND DIESEL ENGINED SHIP (D) FOR A TWO MONTH TRIP

TOTAL DURATION OF TRIP TWO MONTHS; AT SEA 27.5 DAYS; IN HAVEN 28.0 DAYS; SPEED 11.4 SEA MILES

		Motorship (D)	Steamer (S)
(1)	Fuel:		
	D: sea trip, 27.5 x 11.9 ..... 328 tons		
	20 tons		
	in haven ..... 30 tons		
	auxiliary boilers ..... 26 tons		
	404 tons,		
	at marks 26.56	10,710	
	S: coal, 1250 tons, at 15.80 marks per ton		19,730
(2)	Wages:		
	D:	3,774	
	S:		5,070
(3)	Lubricants:		
	D: machine oil, cylinder oil, grease, kerosene	1,820	
	S:		270
(4)	Depreciation:		
	D: 10 per cent on ship		
	12 per cent on engine equipment.	24,680	
	S: 10 per cent on ship and engine.		18,900
		40,984	43,970
	Operating costs per ton carrying capacity	2.57	2.74

ships is the lubricant outlay. Lubricants such as machine oil, grease and kerosene on Diesel engine ships constituted an expense of 1820 marks, while the steamer cost in this respect was only 270 marks. While steam engine plants on seagoing vessels require a lubricating oil consumption of 0.4 to 0.5 kg. per indicated h.p.-hr., in the case of the Diesel engine ships it was found that the demand for lubricants rises to 2.4, 2.5 and even more kg. per indicated h.p.-hr.

On the whole, it was found that these four sources of expense, fuel, wages, lubricants and depreciation, even at low prices for oil, have shown an advantage in favor of the Diesel engine driven vessel, but an advantage which is not very striking. In this connection, however, there have been left out of consideration the cost of general maintenance and unforeseen expenses, which so far have been quite heavy for fuel engine driven ships. Apart from "child age troubles," to which all new types of engines are naturally subject, it has been found in general that Diesel engines, when in constant operation, require a far greater amount of attention on board ship than is the case with steam engines. Cases have been known where Diesel engine ships have been at work for two to two and a half years without giving any trouble, and then suddenly all sorts of disturbances, such as the ripping of cylinder cover connections, cooling water jackets, etc., started in.

A particular source of trouble is the ripping of the cylinder covers; this can be obviated, however, by proper cooling inside the cover, elimination of angles, etc. A further source of trouble is that often a brief interruption of the work of the cooling water pump or decrease in its output can cause grave troubles. The worst, however, is that such troubles are much more serious in the case of the Diesel engine ships than with steam engines because if they happen abroad in an unfrequented place, there may not be a supply of parts available and the ship is apt to be kept out of service until such parts are supplied and repairs made.

While the consumption of oil in the working cylinder of a Diesel engine is thermally more efficient than that of a steam engine, quite large amounts of heat are still lost, approximately 60 per cent. Many attempts have been made to utilize this heat on board ship; for example, by means of heating steam boilers by the exhaust gases of the engine or by heating water. The attempt to utilize exhaust heat directly for preheating the oil in the tanks involves a danger in that if the water-pipes start to leak, the water will get into the oil and this must not be allowed under any circumstances. In fact, as the oil usually has a certain percentage of water in it, it is advisable before using it in the engine, to give it an opportunity to stand still for 10 or 12 hours so that the water may separate from it. The simplest way to do this is to provide tanks of capacity approximately equal to half of a day's consumption and to have cocks at the bottom through which water might be discharged after it has been allowed to settle.

The idea of using exhaust gases from the Diesel engine under auxiliary boilers is easy to understand but does not appear as a particularly happy solution of the problem. There ought to be rather a tendency to eliminate steam boilers on engine driven ships entirely. Up to the present time most designers install steam power for such auxiliary purposes as winches, anchor hoists, rudder engines, as well as for heating. There are even Diesel engine ships upon which, in addition to the main power plant, there are, used for various auxiliary purposes, steam, compressed air, electric energy and even water under pressure, but such ships will be considered only as curiosities in the future. On the other hand, however, there have lately been built ships (like the "Fionia") on which, with a Diesel engine plant of 4,000 i.h.p., the entire auxiliary machinery and pumping plants are driven electrically, although even there, there is an auxiliary steam boiler installed exclusively to supply the fairly large demand for hot water for heating and bathing on the passenger side of the vessel.

Among the auxiliary machinery, an important part belongs to the engine starting device. The Diesel engine cannot be started on oil and on board ship it is customary to use compressed air for starting and reversing purposes, the compressors being connected directly on the crank shaft or having separate driving motors of their own. If one considers that a main engine plant of 2,000 indicated horse power requires a compressor of about 200 h.p., it becomes clear that such a compressor, with its driving engines, requires quite a lot of space and this sometimes leads to the

adoption of the otherwise less convenient direct-connected compressor.

As regards the carrying capacity of Diesel engine ships, the author states that in the first installations an effort was made to secure a high degree of reliability and the saving in weight was therefore low. Later on, however, savings in capacity were effected; thus between the steamer Santa Anna (6400 tons) and the motor ship Monte Penedo (6410 tons), the latter had the extra carrying capacity of 450 tons. It must be borne in mind, however, that this difference includes the difference between the bunker contents of coal and oil amounting to 357 tons, so that the proper decrease in weight of the motor ship with the bunkers empty, was only 58 tons. The loading space saving in the ship was also very modest and amounted to only about 1.97 per cent. (*Die Grossdieselmotorschiffe, ihre Wirtschaftlichkeit und ihre Zukunft,* Wm. Scholz, *Zeits. des. Vereines deutscher Ingenieure,* vol. 59, no. 5,, p. 86, January 30, 1915, 7 pp. *sc*).

Railway Engineering

BALL BEARINGS ON ELECTRIC RAILWAY CARS

The article describes tests made on the use of ball-bearings in various connections on railway rolling stock and the results obtained. Its interest lies in the fact that in the test described, a wider application of ball-bearings has been made than is usually the case.

The first cars provided with ball-bearings were placed on the Montreux-Oberland Railway in 1910—two 4-axle second-class cars, with bearings made by Schmidt-Roost, of Oerliken, Switzerland. In 1911 seven more 4-axle cars, among them a diner, were equipped in a similar manner. The results were so satisfactory that the axles of all the new motor cars, passenger trailers and freight cars were equipped with ball-bearings, and at present the line has 39 cars so equipped. In new orders for rolling stock the application of ball-bearings was not limited to the axle journals, but for the first time in Switzerland, they were also introduced between the underframe and bogie of 4-axle cars. This arrangement,

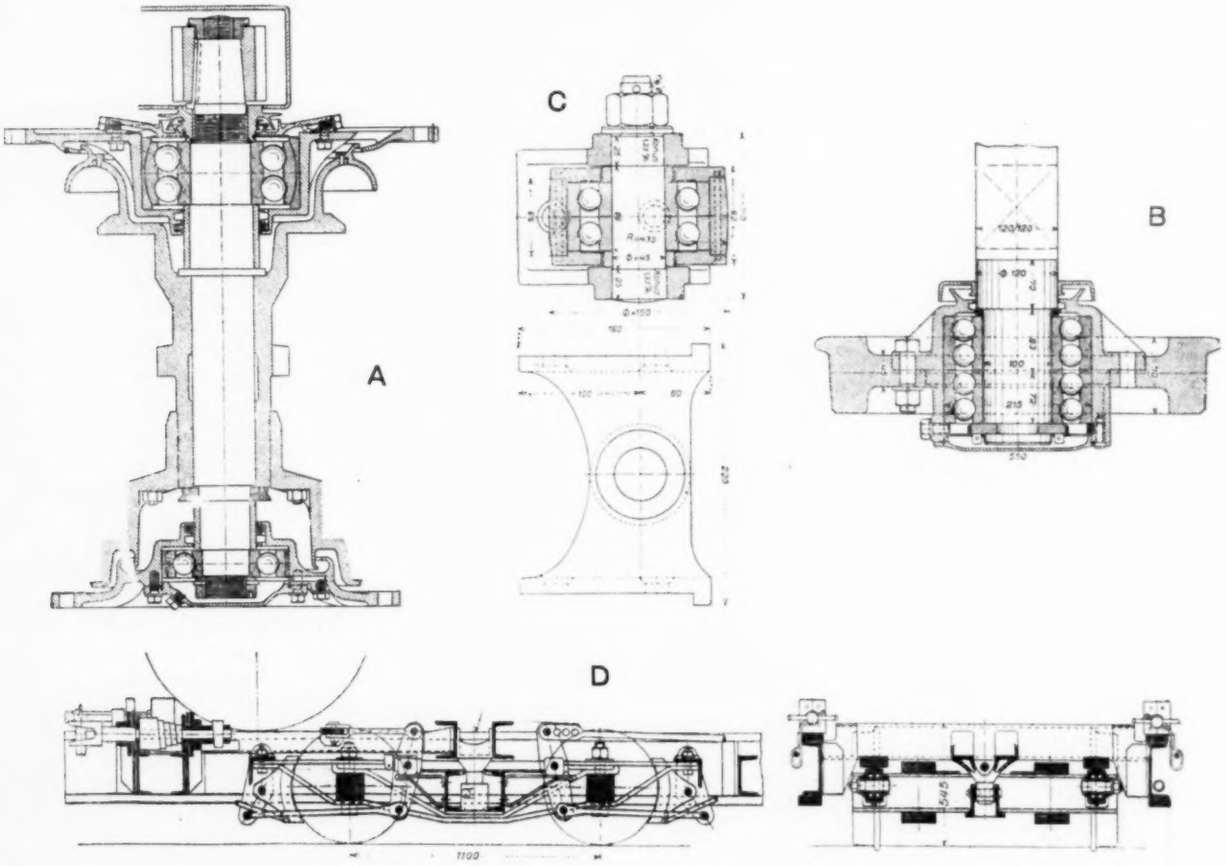


FIG. 1 BALL BEARINGS ON ELECTRIC RAILWAY CARS

shown in Fig. 1A, was particularly convenient on this line with its numerous and very sharp curves which had to be handled by comparatively long cars. The results were perfectly satisfactory, smoother runs being obtained on curves of small radius.

Then a new step in the same direction was taken, and on two new motor cars, the motor shafts were also equipped with ball-bearings, and altogether eight motors were so equipped, each of them having the remarkable (for narrow-gage) average output for one hour of 114 h.p. While there never was any trouble with the ball-bearings in axle journals and between the underframe and bogie, the ball-bearing arrangement in the traction motors, where the designer was very much limited by the space available, has caused some

trouble at first, but worked perfectly later, notwithstanding the very high pressures on the bearings and the violent lateral shocks due to handling sharp curves with low-lying motors having no spring protection laterally. This is particularly so, as the motors run at 1660 r.p.m., corresponding to a maximum speed of run of 45 km. per hour, with a wheel diameter of 900 mm. (35.4 in.) and a ratio of gear transmission of 1:6.286.

Fig. B shows the way the motor armature shaft is located in its ball-bearings. Attention is here called to the spherical hollow-cut in the casing of the bearing which permits the rings holding the balls in place, a certain amount of motion, to take care of the bending of the shaft, and also an automatic adjustment without any jamming or one-sided pressure.

An interesting novelty in the application of ball-bearings is represented in the platform bogie shown in Fig. C. Out of the three bogies serving for the support of standard cars, weighing a maximum of 30 tons, two were equipped with sliding journals and a third with ball-bearings—Fig. C. This bogie is provided with rigid wheel axles, rigidly connected with the bogie, and the wheels loosely set on the axle and running on ball-bearings. It is said that this construction not only has the advantage of having a low internal resistance, but results in a soft and free of friction handling on curves, because the two wheels of the same axle can rotate independently one of the other.

In order to compare as precisely as possible the natural resistances of the two different types of bogies, experiments were carried out in June 1914, with the registering dynamometer inserted between the bogie and the motor car. In order to be able to compare better with each other, the results obtained, without their being affected by the difference of the weight of the bogies, the total weight of the loaded trucks was the same, 26 tons, in all test runs. Nevertheless, because of continuous vibration and numerous curves following one after another, and also because the dynamometer had no device for damping, no claim to absolute precision is made here. A somewhat more reliable state of equilibrium appears to have been maintained, however, on a straight line stretch about 250 m. long and the record of the dyna-

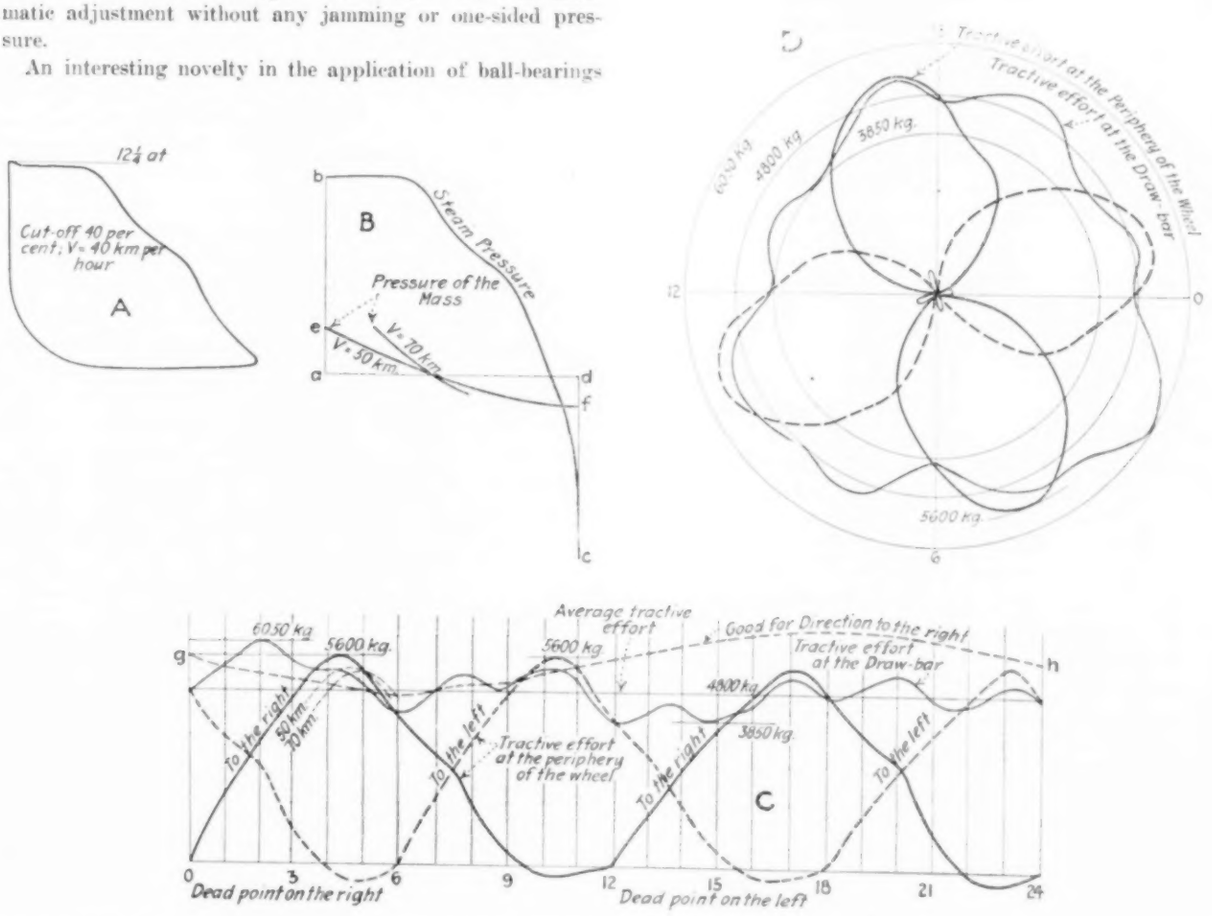


Fig. 2. A Steam Diagram; B Over-Pressure Diagram; C Linear Peripheral Force Diagram of a Twin Steam Locomotive; D Same as C, in Polar Diagram

mometer showed there a natural resistance of 5.3 kg. per ton (metric) with a slide bearing and 2.3 kg. per ton with ball-bearing.

A further serious argument in favor of ball-bearings is that first they have to be lubricated approximately once in six months as compared with 10 to 15 days in the case of a motor or passenger trailer car equipped with slide bearings, and further, that the life of the ball-bearing is from 10 to 15 years as against the life of a slide bearing of about two years. (*Erfahrungen mit Kugellagern im Betriebe der Montreux-Berner-Oberland-Bahn*, R. Zehnder-Spoerry, *Schweizerische Bauzeitung*, vol. 65, no. 5, p. 49, January 30, 1915, 4 pp., 4 figs. *de*).

UTILIZATION OF ADHESION WEIGHT IN STEAM LOCOMOTIVES.

The article discusses the utilization of adhesion weight in the case of steam locomotives, and the proper design of locomotives.

The author claims it to be inadmissible to use as a measure for the determination of the adhesion, the sum of rotating forces on the right and left drivers. He states that it is not safe to rely on what is known as "starting diagrams." There is no such thing as a starting diagram proper. If a locomotive were to start twenty times, the first set of indicator diagrams would come out different in every case in accordance with the crank position at starting, position of the throttle, the experience of the engineer, etc. The diagrams which the author uses, are not starting diagrams proper, but have been taken at average speeds, say 20 km. per hr., that is, during the period of acceleration of the train, and even such diagrams are not fully sufficient for the determination of the utilization of adhesive weight.

He discusses further the interesting question of the behavior of a steam locomotive as compared with that of an electric locomotive during the period of acceleration. In Fig. 2A is given a steam diagram for a cut-off at 40 per cent. Although it has been taken at 40 km. per hr., the throttle losses are so slight that it might be good for 10 to 20 km. per hr. just as well. At the low velocities of 10 to 20 km per hr., the action of the pressure of masses on the crank pin can be neglected and the forces acting, in the direction of the axis of the cylinder, on the driving pin at various positions of the crank can be obtained from the ordinates of the over-pressure diagram *abcd* in Fig. 2, from which, in the usual manner, the diagram of the peripheral forces can be drawn, with proper consideration of the finite length of the driving rods. Such diagrams are shown in Figs. C and D. In Fig. C, the pulls acting on the right and left wheel rims are plotted as ordinates over the developed wheel circumference.

Owing to the elasticity of the axes, it is not permissible for the purpose of determining the value of friction of wheel against the rail itself, to add together the values of forces acting on the right and left wheels and then count them as the adhesion draft referred to the axes or an ideal wheel. As a matter of fact, the value of friction draft does not have to be considered at all as far as the utilization of adhesion weight on a wheel is concerned. In Figs. C and D it is plotted as a thin wavy line with a maximum value of 6050 and a minimum value of 3850 kg. At the same time, the maximum value of the tractive effort never coincides with the maximum value of utilization of adhesion weight on the wheels since the maximum peripheral force on the driving axis is distributed fairly uniformly over the right and left wheel groups, (it varies from 6050 kg. to 3250 or 2800 kg.). The average value of the tractive effort, as shown in Figs. C and D, can be taken at 4800 kg. and it has the same average value in the electric locomotive with rod drive used for comparison with the steam locomotive. If in the electric locomotive direct current is used, then the tractive effort is of constant value throughout. With polyphase current, because of the overlapping of phases, it is nearly constant, while with single phase it varies quite considerably. In the first two cases, the average tractive effort of 4800 kg. represents also the maximum value acting on a single wheel at the instant when the crank of the counter driving wheel is at its dead point, the minimum value being zero. It appears from Figs. C and D, therefore, that a two-cylinder steam locomotive with outside cylinders, as compared with an electric locomotive of the same average tractive effort, develops a peripheral pressure on the wheel, in so far as it affects the utilization of adhesion weight, 16.5 per cent greater and this result is good even when the conditions assumed do not favor the steam locomotive, viz., cut-off of 40 per cent and only a 6.3-fold length of driving rods. Several circumstances may, however, materially improve the condition of work in steam locomotives.

In the above example it was assumed that the locomotive had outside cylinders, and that the moments of torsion originated on one side of the machine in the driving and coupling pins, were transmitted directly through the spokes of the wheel on to the "friction coupling" between wheel and rail. But when there are inner cylinders and cranked axles, then the moments of torsion of one side of the machine will be transmitted not exclusively on to the wheels on one side, but, in accordance with the torsion of the axis, will be distributed in a non-uniform manner over both the right and left sets of wheels. As a result, the maximum stress which falls on one wheel, will be reduced. A limit in this respect is set by a locomotive with a Klien-Lindner driving axle, in which the tractive effort is transmitted exactly along the center of the axis on to the hollow wheel. In this case, the maximum tangential force on the circumference of the wheel is only about half as large as in an electric locomotive with rod drive and equal tractive effort. As far as the utilization of adhesion weight is concerned, the Klien-Lindner locomotive and the locomotives with two inner cylinders, and with three or four cylinders lying side by side, are all of them superior to electric locomotives, because tractive efforts which have to be transmitted by a single coupled set of wheels, do not reach quite as high maximum values.

The locomotive is, however, stressed up to the limit of friction not only during the acceleration of the train, but also at comparatively low velocities, especially when pulling upgrade. For how long and how often adhesion force should be used in driving at higher speeds is purely a question of boiler and grate utilization. Locomotives used on uneven grades have to be prepared to stand particularly high stresses in this regard. At high speeds, the action of pressure of the masses on the driving pins (the magnitude of which is indicated by the ordinates of the area, *adfe*, Fig. B) must not be neglected. The ordinates of the diagram *ebcf* show the piston pressures acting on the driving pin when the speed is 50 km per hr. and Fig. B permits one to estimate the piston pressures also at speeds up to 70 km. The action of the pressures of masses is of an equalizing nature; that means that because of it the piston pressures become more and more uniform, and the same applies to the tractive efforts acting on the periphery of the wheel, as indicated in Fig. C by the dotted curves between the ordinates 3 and 6. Since the pressures of masses do not affect the average tractive effort of 4800 kg, the excess of peripherel force action on the wheel in steam locomotives is less than the maximum of 4800 kg. of electric locomotives. Strictly speaking, the steam diagram of Fig. A is not precisely correct for velocities of 50 and 70 km., since greater throttling losses appear at higher velocities. The latter, how-

ever, are so dependent upon the dimensioning of the organs of steam distribution that in this connection it cannot be considered as of material importance.

One more point has to be mentioned, and this is that under certain conditions, the steam locomotive is at a disadvantage as compared with the electric locomotives, in as far as the utilization of adhesion weight is concerned, and this disadvantage lies in the fact that the centrifugal forces of the balancing masses of the counterweights oppose the action of the adhesion weight. In the two-cylinder locomotive, however, with the driving gear running in counter-directions and in the four-cylinder locomotive of the Borries type, the equalization by counterweights is omitted and therefore the utilization of adhesion weight is not affected at all.

The author comes to the general conclusion that in steam locomotives there are considerable variations in the utilization of adhesion weight not dependent upon the construction proper. Theoretically, however, it may be assumed that the steam locomotive utilizes the adhesion weight just as well and perhaps better than the electric locomotive and that the parts of a steam locomotive serving for the transmission of power are more favorably stressed than the mechanical parts of the single-axle polyphase-current electric locomotive.

Die Ausnutzung des Reibungsgewichtes bei der Dampflokomotive, Dr.-Ing. Ludwig Schneider, *Dinglers polytechnisches Journal*, vol. 329, no. 50/51, p. 696, December 19, 1914. 5 pp., 4 figs., *t*).

Steam Engineering

Gas Explosions in Lignite Fired Boiler Plants.

The article discusses explosions of gas in lignite fired boiler plants and methods of their prevention.

In German practice, several accidents are recorded of gas explosions in the flues of steam boiler plants. Such a case, for example, occurred in a rolling mill boiler equipped with a step grate. In that case, a lignite, rich in gas, was used and the fireman was in the habit of piling large masses of fuel over the bed. Once, shortly after he had loaded up the grate in that manner, there was a tremendous explosion which did a lot of damage to the plant.

Another case of considerable interest occurred, also in a German plant, where a new boiler had been installed and was being heated up. At first a wood fire was lighted on the grate of a Ten-Brink furnace. Over this wood fire the fireman piled up a heap of dry Bohemian nut lignite, high enough to reach the tip of the funnel of the hopper, the damper being wide open. As soon as the coal was piled up in this manner, it was noticed that the draft fell off and smoke began to come out of the grate. This was followed suddenly by a tremendous explosion which did a large amount of damage and, among other things, destroyed the boiler setting.

After things had been put back in shape, another attempt to fire up the plant was made, and the next day there was a second gas explosion which did, however, somewhat less damage than the first. As the concern which contracted for the installation of the boilers was under the impression that these accidents were due to lack of sufficient draft, they have replaced the old smoke stack (22 m. high and 0.5 m. wide), with a new smoke stack 35 m. high and 0.75 m. in diameter), even though with the old smoke stack there was a draft of more than 11 mm. of water. The hoped-for results, however, failed to materialize, as several days after operations were resumed, there occurred a third explosion more violent than any of the preceding ones, which indicated that the cause should be looked for elsewhere than in the conditions of the draft.

Further observations have finally shown that the inclination of the grate of approximately 48 deg. was too steep for the kind of lignite used. Accordingly, the fuel used to slide down without being consumed and in this way covered up the fire so that what occurred was to a large extent similar to the case of the fireman in the first explosion, who heaped too much fuel on the fire. A new grate was put in with an angle corresponding to the angle of repose of the lignite and no more trouble was experienced.

The German associations for boiler inspection have collected quite a large amount of material on this subject and the fundamental rule which they developed is *to look out that the boiler furnace should not become practically a gas producer.* The firing arrangements should be adapted to the kind of fuel used and the fireman should be particularly cautioned to maintain the entire bed uniformly covered with fuel to a height that will permit the flame to break easily through. If this is done, all the gases developed can rapidly pass out and be burned above. The thickness of the bed depends upon the kind of fuel used. If it is in large lumps so that both the flame and gases can easily pass through it, and of a nature of coke, the bed may be thicker than with fine material rich in gas.

The article goes on to point out measures similar to the above. Among other things, the author recommends opening the fire door, ash door and smoke stack damper from time to time and to admit as much air as possible into the flues, so as to remove any dangerous gas mixtures, or at least to lower their temperature and change their combination. Where the boiler has dead corners in which hot gases may accumulate without being subject to the action of the smoke stack draft, proper openings should be provided to drive such gases into the smoke stack. It is also a good idea to place in various parts of the flues, safety valves opening outward so that, if a gas explosion should occur, its action would be less destructive to the general system. (*Verhütung von Explosionen bei Braunkohlenverfeuerung in Kesselanlagen*, P. M. Grempe, *Braunkohle*, vol. 13, no. 46, p. 614, February 12, 1915, 3 pp. *p*).

Explosion of a Locomobile Boiler

The boiler shown in Fig. 3A which exploded in October 1913 in Gehersberg (Upper Bavaria, Germany) was made in Germany in 1873 and licensed for a working pressure of 5 atmospheres absolute. Its heating surface was 7.2 qm. (77.4 sq. ft.), the area of the horizontal grate built-in in the fire box, 1.43 qm. (15.38 sq. ft.), a total volume of 108 cbm. (3814 sq. ft.), with a steam space only 150 mm. (5.90 in.) high. The sheets of the boiler were connected with each other by simple lap riveting The locomobile was used for farm purposes.

On the day of the explosion, it was to be used for driving a threshing machine and was being heated up after a stop of 14 days. The heating was started at half past five in the morning and at half past six the boiler showed a pressure of 2 atmospheres. The attendant considered this pressure too low and started to heat it faster; soon after, the

boiler exploded with a tremendous noise, throwing large parts at a considerable distance. The water gage was not broken but much damage to property was caused and two men were injured.

The boiler was subjected to an internal inspection in April and while inward bulging was observed in the crown sheet, it did not appear to be of particular depth. It was again inspected, externally, in the fall and no dangerous developments were found. As to the causes of the explosion, it is rather difficult to form a precise opinion because the parts were not inspected until five days after the explosion when the pieces of the boiler were thoroughly covered with dirt and rust. Since, however, it was found that the crown sheet remained in practically the same state as when it was inspected before and a certain amount of scale was still sticking to the fire box walls and fire tubes, it seemed to be clear that the explosion was not caused by lack of water.

The state of the plates was such as to make it impossible to determine whether the explosion was due to previous cracks. It might be possible that it was due to excessive pressure although the attendant states that immediately before the explosion the pressure indicated was only 2 atmospheres. This may be true but it appears rather unusual that after a heating of only one hour in the early morning, there should be a pressure of 2 atmospheres after the boiler has been kept cold for a long time and especially in view of the fact that the water must have been quite cold (4 to 5 deg. cent. — 39.2 to 45 deg. fahr.). The attendant, further, tested the water gage before starting the boiler and found that the water flowed through all of the cocks. One may conclude from this that, by way of precaution, he overfilled the boiler with water and if such was the case, it might be possible that the water, because of its expansion when heated, filled up almost entirely the very small space remaining in the boiler, so that when the steam began to form, the pressure on the boiler walls began to increase very rapidly. When the manometer showed 2 atmospheres, this pressure appeared too small to the boiler attendant for starting the engine; he continued to heat it and a few minutes later the boiler exploded. These few minutes may have been quite sufficient to raise the pressure to such a height as to cause at somewhat weaker places a rupture of the boiler walls and as soon as this happened, the superheated boiler water suddenly expanded into steam and thereby produced the explosion. It is believed, therefore, that in the final account, the explosion was due to excessive filling with water. It is possible old cracks, not previously noticed, may have contributed to the weakening of the shell. (*Explosion eines Lokomobil-Dampfkessels*, Müller, *Zeits. des Bayerischen Revisions-Vereins*, vol. 18, no. 23, December 15, 1914, p. 211, 2 pp., 5 figs. *dp*).

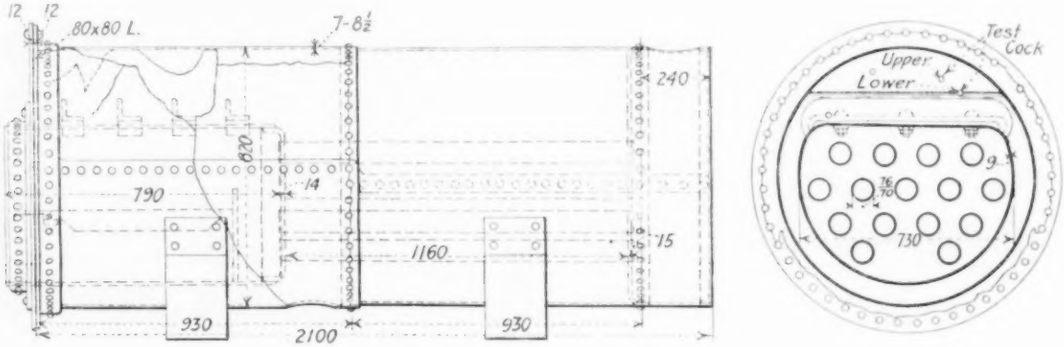


FIG. 3 LOCOMOBILE BOILER WHICH EXPLODED

COMMUNICATIONS FROM THE CHEMICAL LABORATORY OF THE BAVARIAN ASSOCIATION FOR BOILER INSPECTION

Feed water with high soda or mud content tends to form wet steam especially in heavily loaded boilers. In such cases, and particularly where the feeding of the boiler is intense, some of the boiler contents, that is, water and mud, are easily carried away with the steam. Mud is particularly easily carried over into the steam piping if the feed water contains oil. In that case, the oil drops either settle on the deposited particles of mud or, where the oil contains saponified particles, it helps to form foam. The mixture of boiler mud with oil has a very low specific weight, and floats on the surface of the water, while if it were free from oil, it would settle in the boiler at the spot where the movement of the water is least.

In a steam plant, considerable amounts of mud have been carried over by superheated steam into the pipes and heating elements and there have caused considerable trouble, which required tedious cleaning. In addition to fresh water feed water containing oil was also used. The analysis of the whitish deposit in the pipes and radiator elements, made in the chemical laboratory of the Association, showed the presence of considerable amounts of calcium dioxide but only 1.7 per cent of oil. When dried, this mud was very light and voluminous, 100 g. occupying a space of about 450 ccm.

In another case, in a superheater steam boiler of a locomobile, purified feed water was carried over into the superheater because of the large content of soda and the intensive feeding, and in the superheater was converted into steam. The salts in the water in the form of fine dust, reached the steam chamber of the engine and there, together with the cylinder oil, formed a black-grey crust 2 to 3 cm. (0.78 to 1.18 in.) thick. At first oil was blamed for this crust formation, but laboratory investigation proved beyond doubt that it was due to the action of the boiler. A quantitative analysis of an average sample of the crust gave the following results (in per cent):

Sodium carbonate	48.0	per cent
Sodium sulphate	26.5	per cent

Sodium chloride	6.7	per cent
Original material soluble in toluol	3.0	per cent
Material soluble in toluol in the mass obtained by decomposition with hydrochloric acid of the residue after the first extraction with toluol	1.1	per cent
Carbon from decomposed cylinder oil	7.5	per cent
Calcium carbonate	0.7	per cent
Silicic acid	0.16	per cent
Iron oxide	0.13	per cent
Moisture and traces of magnesium as residue	6.21	per cent

This shows that the crust formed in the steam chamber of the locomobile consisted to the extent of nearly 81 per cent of easily soluble salts which are always present in superheated feed water made from purified water, viz., soda, sodium sulphate and common salt. The carbon comes from the cylinder oil decomposed by continued action of superheated steam. The parts soluble in toluol are partly non-decomposed lubricating oil and partly asphaltum materials either initially present in the oil or formed in it through the processes of pitch formation. (*Mitteilungen aus dem Chemischen Laboratorium des Vereins, Zeits. des Bayerischen Revisions-Vereins*, vol. 18, no. 23, p. 213, December 14, 1914, serial article, not finished. *e*).

German Progress in Steam Boiler Firing.

A continuation of the article describing new types of grates and steam boiler firing systems abstracted in *The Journal*, March 1915, p. 185.

C. Fischer of Frankfort-on-Main uses a pair of roller levers for driving the fuel-throwing shovel of his stoker, (German patent No. 279,078). During the rolling, motion initiated by the driving lever is transferred to the driven lever in such a manner that the latter moves with a greater amount of force but at a lower velocity, on account of which, although the force of the motion decreases, the motion itself is accelerated all the time. Fig. 4A gives a diagrammatic side view of one of the designs of this drive. The device for moving the shaft *a* of the fuel-throwing shovel consists of two roller levers *b* and *c*, of which the first is the driving one resting on the shaft *d* while the other one is a driven lever and moves the shaft *a*. In the frame *e*, there is provided a bell crank *f* which is moved by the crank disc *h*, through the rod *g*. The bell crank *f* acts directly on the driving roller *b*. In order with such an arrangement to secure a certain amount of adjustability, pedal *i* of the bell crank is made adjustable by means of a hand wheel. In order further to secure continuously variable drive of the lever *b* and through that, of the fuel-throwing shovel, the lever is located on an eccentric *k*, rotatable by means of a locking device *l* and *m*. The motion of the wheel regulating the admission of the fuel to the fuel-throwing shovel, resting on the shaft *n*, can be varied in a similar manner by locating the locking device *o.p.* on the shaft *n* and by connecting it, by an intermediary lever *q*, or the crank disc *h*. The driving lever *b* can also be designed as a laminated plate spring so as to secure a certain amount of elasticity.

A peculiar stoking device has been obtained by J. Hierold of Erfurt (German patent No. 279,469). The fuel is delivered to a rigid plane grate from a hopper located so as to secure a predetermined height of fall, and is moved forward by a circular brush engaging into the grate openings. Fig. B gives a vertical longitudinal section through this stoker as built-in in a fire tube boiler. The grate is here supported by a rigid frame *f* in such a manner that the circular brush *a* moves on the upper part of the grate from the front to the rear end, and on the lower side from the rear end towards the front end, without striking any part of the grate. To make the disc *a* move, there is located on both sides of the grate frame a chain drive protected from the action of the fire. The chain drive and the fire plate *b* extend somewhat forward of the boiler front wall. On that part is delivered the fuel from the hopper *c*, through a height of fall regulated by the valve *d*. The baffle plate *g* serves to limit the extension of the fire and to protect the hopper.

In draft regulators which regulate the draft in accordance with the steam pressure, it is a usual practice to employ water under pressure for actuating the regulator valve. In such a case, the steam pressure acts on a membrane through a column of water of condensation which accumulates over that membrane, and the latter, in its turn, actuates the valve in the piping containing water under pressure. There is, however, a difficulty in such an arrangement due to the fact that the column of water of condensation, owing to its friction against the walls of the piping, opposes the impulses which have to be transmitted to the membrane, this resistance being proportional to the steam pressure exercised on the column of water. As a result of that, the membrane begins to move only when the variation in the boiler pressure is greater than the frictional resistance of the water column in the piping which contains the water of condensation.

The Apparatebau- und Herdkessel- Industrie Karl Alt & Paul Jerome in Strassburg i. E., Germany, has patented (German patent No. 277,331) a draft regulator which is claimed to be immune from this source of trouble. Inserted in the piping between the membrane and the boiler, there is a device which reduces the boiler steam pressure before it begins to exert a pressure on the water column acting on the membrane, and this reduction occurs in such a manner that to certain pressure variations in the boiler, there correspond greater pressure differences on either the water column or the membrane; further, shocks uninterruptedly following one after another produce a certain restlessness in the membrane, which renders harmless its inertia with respect to motion. By means of these two separate actions, a high sensitiveness of the membrane is secured and it is made to respond to pressure variation of $^1/_{20}$ of one atmosphere. As a result, should the pressure rise by $^1/_{20}$ of an atmosphere over the working pressure, the slide damper is immediately closed and when the pressure falls by $^1/_{20}$ of an atmosphere the slide damper is opened.

In order to ensure that, where steam pressure draft regulators are used, the opening of the fire box door should bring about the closing of the slide damper, J. Matter has designed the device shown in Fig. C, (German patent No. 276,859). The slide damper *e* is suspended from the hydraulic piston *c*, loaded with the weight *d*, the piston moving in the hydraulic cylinder *b* connected with the pressure tank *a*. The admission of water to tank *a* and cylinder *b* occurs through the valve gear operated by a rod dependent upon the opening and closing of the fire box door. Beside the cylinder *b*, there is provided also a steam cylinder *g*, supplied with steam under boiler pressure by which the piston *h* is raised by the steam pressure against the pressure of the spring *i*, surrounding that piston. The piston *h* carries in its lower part a strongly built flange *l*, which overlaps the flange *k* on piston *c*. Since

both pistons are guided vertically in their guide rods, the piston *b* is carried away by the piston *h* and therefore the slide damper is adjusted in accordance with the steam pressure in the boiler. When the fire box door is opened, the piston *b* rises high enough to have the slide damper *e* entirely closed and after the closing of the fire door, comes back again to a position, the height of which is determined by the location of the flange *l* or piston *h* and which corresponds exactly to the steam pressure prevailing in the boiler.

Ch. Hülsmeyer has devised a method of regulating the process of combustion by the weight of the fuel on the grate (German patent No. 277,332). One design of this rather complicated arrangement is shown in Figs. D, E, and F. The grate *a* is made freely oscillating about the point *b* and consists of a tuyere plate *c*, grate bars *d*, fire bridge *e* and supplementary air piping *f*. The fire bridge *e* is connected by bolts or angle irons with *c*, in which are located the removable grate bars *d*. The end of the grate consisting of the bed *c* is made freely oscillating and rests on the shaft *i* which is kept in its position by the springs *k* and is balanced by the weight of the freely oscillating part of the grate. The shaft *i* is provided with a cam *l*, which in a normal state of operation keeps the valve *m* closed. When the grate is loaded with fuel, the tip *g* of the tuyere plate *c* presses so hard on the cam *h* that the cam *l* opens the valve *m* and admits steam through the piping *o* to the nozzles *n*, *n*¹, etc. The amount of steam admission varies with the course of combustion and the load on the grate. The springs *k* are located on eccentric cams on the fire door *p* so that when the latter is opened, an additional tension of the springs is obtained which results in the valve *m*, i.e., the steam admission to the grate, being closed. The rate of air transmission through the layer of fuel varies as the load on the grate, and the former may be utilized in order to obtain a still closer regulation by inserting in the separate air chambers a measuring pipe with several openings. This pipe may be filled with a liquid the level of which would vary as the draft, that is, as the resistance of the fuel bed. If this device for measuring the draft be filled with mercury and suitable electric contacts be placed in the glass walls, it would be possible to regulate automatically the air admission to the various sections of the grate (*Neue Patente auf dem Gebiet der Dampfkesselfeuerung*, Pradel, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 38, no. 6, p. 45, February 5, 1915, 2 pp., 7 figs. *d*).

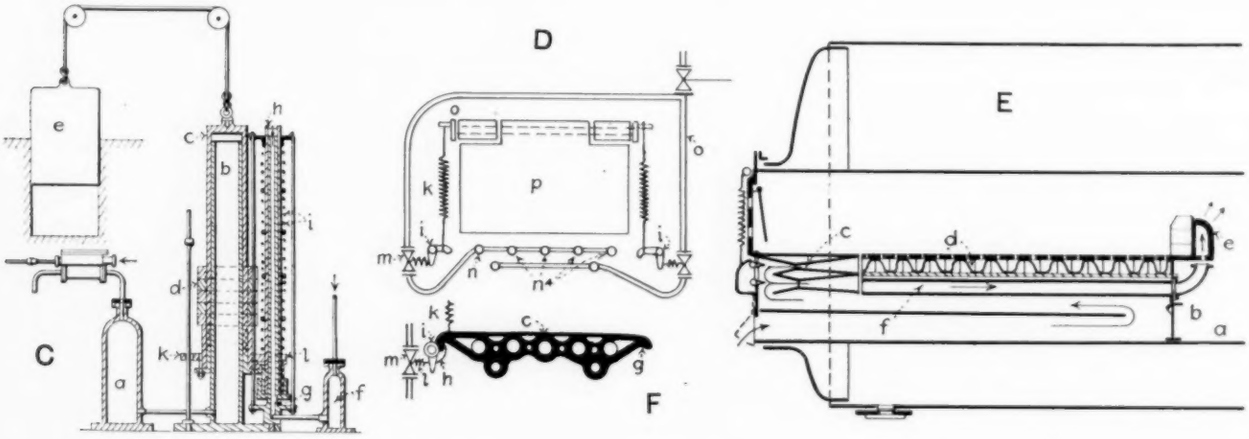


FIG. 4 NEW DEVICES IN BOILER FIRING

ENGINEERING SOCIETIES

ENGINEERS' SOCIETY OF PENNSYLVANIA

Journal, vol. 6, no. 12, December 1914, Harrisburg, Pa.

SERVICE AND TESTS OF MAYARI INCLINE CABLES, James E. Little

The paper describes tests of inclined cables on an iron mine property in Cuba.

The Mayari mines in Cuba operate a rather unusual inclined cable railroad over which 50 ton capacity steel cars can be lowered in trains of three through a total vertical height of 1084 ft., the maximum grade being 25 per cent. These conditions of operation require a cable having a working strength of about 150,000 lb. The inclines are only for the purpose of lowering loads and the conditions are therefore quite different from those met with on a hoisting incline. The machinery includes a double 30 in. x 30 in. steam engine but the power is employed merely to start the cars moving, though occasionally it is necessary to use steam over points where loads do not sufficiently overbalance the empty side.

The article describes in some detail the arrangement of the cables. A cable is carried along the track on cast manganese steel rollers with rolled manganese steel axles cast in, the axles running in rough cast iron half bearings. After three years' service, the original manganese steel rollers show no apparent wear. The tensile strength per sq. in. metallic area in cable section has been found to be from 175,000 to 182,000 lb. while the actual tensile strength of the wires vary from 728,000 lb. to 751,000 lb.

The article describes fully the tests made on the cables.

The object of the tests was to ascertain the relative strength of the different cables when new, as well as the strength of used specimens, this information to serve as a guide in the operation of the incline. Tests of three cables delivered between December 1912 and October 1914 have shown that the last cable is about 3.5 per cent stronger than the average of its two predecessors.

To soften the cable in order to be able to cut it in Cuba, where the facilities for doing such work were naturally limited, it was annealed by a wood fire, at a point to be cut. When the socket was being placed on the specimen, this annealed end was not noticed and was not sheared off. Consequently, when tested, it broke at the annealed point 8 in. from the socket under the comparatively low tension of 216,200 lb., while the remaining part of the specimen showed a breaking strength of 451,900 lb. All broken wires at the annealed point showed an unusually high elongation and reduction. In other tests, it was noticed that new cable specimens break with very little warning, each part of the cable taking its proper proportion of the load; the breaking strength was, however, about 80 per cent of the total wire strength, which has proved that the cable was very carefully manufactured.

The article also contains detailed data of tests on the different wires used in cables. Illustrations are given reproducing the photomicrographs showing the condition of the worn surface of the cable wires magnified 50 diameters. It appears that in the manufacture of a cable for such a use, the great problem is the selection and treatment of material so as to reduce the hardening effect on the surface of the wire due to abrasive friction, to a minimum, without unduly sacrificing the tensile strength or flexibility of the cable (14 pp., 5 figs. *e*).

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Vol. 30, no. 8, November 1914, Pittsburgh

Construction Details of the Panama Canal Lock Gates, R. A. Pendergrass

Recent Developments in the Heat Treatment of Railway Gearing, W. H. Phillips (abstracted)

Steam Turbine Mill Drive, J. D. Berg (abstracted)

Discussion on Tests of Large Reversing Engine and Rolling Mill (for abstract of original paper see *The Journal*, January 1915, p. 55)

Recent Developments in the Heat Treatment of Railway Gearing, W. H. Phillips.

The paper discussess the manufacture of railway gearing, partly historically and partly by describing a new method of heat treatment called the B. P. Process.

The development of the railway motor gear in its various stages, (cast iron gear, malleable cast iron, cast steel four-spoke, cast steel six-spoke, forged steel, rolled, hammered and rolled, flexible gear) and the pinion is briefly described. After this, the author proceeds to a discussion of the method of heat treatment and its various processes. The most interesting part is that referring to the B. P. Process which is a secret process, the details of which the author does not state. From the information given, the B. P. Process consists of the following sequence of operations: annealing, machining, quenching and drawing. A careful selection of the raw material and the quenching operation constitute the main feature of the high quality of the product. It is claimed to produce a very hard material, of high tensile strength without losing its ductility. The hardness tapers off gradually from the wearing surface to the center of the tooth.

In the discussion which followed, W. L. Allen stated that the B. P. Process was the outcome of years of research on the part of the Nuttall Company, which aimed to produce gearing having high surface hardness combined with great strength, and to obtain the refinement of structure at less cost than is possible through case hardening. The B. P. Process does not develop as efficient a gear as is brought about through case hardening, but the efficiency which is produced in this process very closely approaches that of the case hardened material and at so much less cost as to make the B. P. grade of gearing very much more economical for the average present day normal operative service.

The same gentleman stated that the Nuttall Company has made a great many experiments to determine the relative merits of pinions cut off forged and rolled bars as compared with pinions made from individually forged or pressed blanks and has found that in some cases the individually forged blanks produce a stronger and better pinion than those made from blanks machined from bars. He stated,

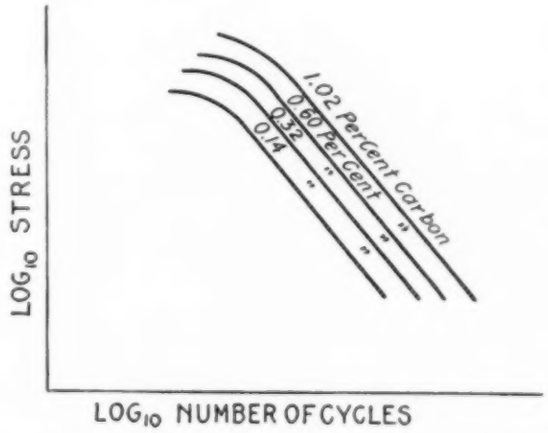


Fig. 5 Diagram Showing the Life of Carbon Steel in Repeated Bending at Various Stresses

however, that it is his opinion that in pressed forging, the material is compressed at the center more than either in hammering or in rolling and the result is that a more homogeneous mass throughout is produced than in the hammered, forged or hot rolled processes. He stated also that some experimenting is being carried on with chrome-vanadium steel for gearing as well as manganese-vanadium steel entirely free from chrome and with the manganese content of about 1¼ to 1½ per cent. No definite data have been obtained.

J. S. Unger said that a process was brought out several years ago to harden the teeth of cast steel gearing by coating the inside of the mould with powdered ferro-manganese. When cast, the temperature of the molten steel was high enough to form an alloy on the surface giving what might be called manganese steel which did not work very rapidly. Another process was brought out in which ferro-chromium was substituted for ferro-manganese. These teeth were very rough and sometimes full of holes and sometimes so hard that it was impossible to machine them. When a gear of this kind was put in service where sudden reversal or heavy starting loads were common, the hard alloyed surface would

sometimes shell off, causing trouble. At one time, experiments were made with the ferro-manganese gear in contact with two ordinary cast steel gears and the manganese gear outlasted the others three to one. While it showed very little wear, it wore out the special gears two or three times as fast as they would have worn out had the three gears in contact been of a softer material, so that the wear was simply transferred from one gear to the other.

W. R. Wigley made a series of tests on the resistance of steel to fatigue and the effect of heat treatment upon that resistance. Four grades of carbon steel were used in making the tests with carbon content of 0.014, 0.032, 0.061 and 1.02 per cent. The pieces were tested by bending them back and forth, thus starting up transverse stresses in the material. For each piece, the bending stress was computed and the number of cycles of bending back and forth counted. By changing the motion of bending in the various pieces of a series, it was possible to determine the life of the material at various stresses. When plotting the results (Fig. 5) a special plot was used; the ordinates were $\log_{10}$ of the stress and the abscissae were $\log_{10}$ of the number of cycles. From these curves, it is evident that at any stress, the higher carbon steels withstood the repeated stresses better than the lower carbon steel. In these tests, however, the loads were applied without impact, and impact might change the relation to some extent. One of the things upset by these experiments, in the speaker's opinion, was the belief in a natural elastic limit. The tests seemed to indicate that there is no such thing as a natural elastic limit at stresses below which a steel will have infinite life against repetitions of load.

STEAM TURBINE MILL DRIVE, J. D. Berg

The article describes a low pressure steam turbine installation for driving two stands of 18 in. three-high mills of the Carpenter Steel Company at Reading, Pa.

This installation is to a certain extent similar to that installed about four years ago at the Calderbank Steel Works of James Dunlop & Company (near Glasgow, Scotland), where a low pressure steam turbine drives a three-high 28 in. plate mill. The Carpenter Steel Company formerly drove their three-high roughing mills by means of a 36 in. × 36 in. simple engine at speeds of from 70 to 100 r.p.m. This engine operated condensing, but its economy was very poor. A little over a year ago a very careful study was made to better the general economy of operation and several methods were considered. The installation of a new compound engine for driving the roughing mills and a modern central condensing system were rejected because, on account of the wide fluctuations of load on the engine and the fact that the normal horse-power required was comparatively small, the first cost and economy of this type of installation were not attractive.

A low pressure turbine generator with condenser and motor drive for the mill would have worked out better had there been a greater demand for power for other purposes in the plant, but as the major part of the power would have

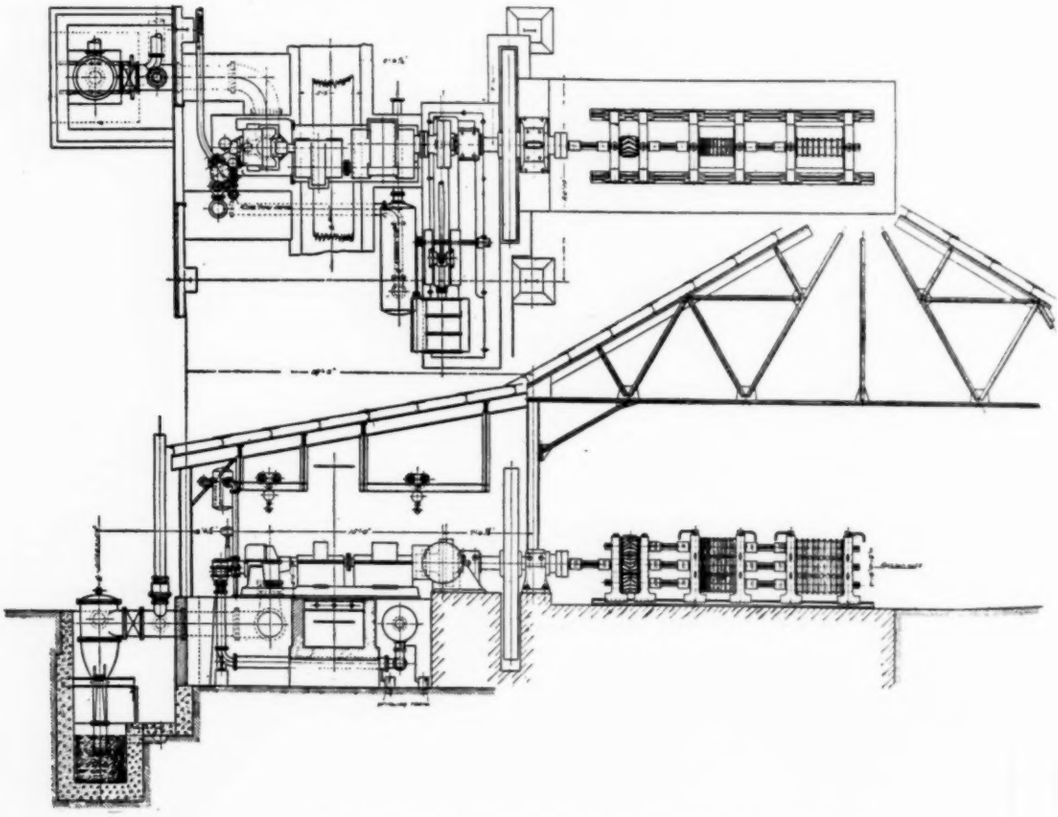


FIG. 6 STEAM TURBINE ROLLING MILL INSTALLATION

been used on the roughing mill, several disadvantages to this scheme were found, such as the high original cost of installation and a loss of from 15 to 20 per cent of the available energy in the steam through electrical generation and transmission. As a result of this consideration, it was finally decided to install a low pressure turbine with a double reduction gear connected to the roughing mill, and to obtain the steam supply for the turbine by running the finishing mill engine non-condensing.

The article describes in detail this new installation of which Fig. 6 shows the general layout. Very careful attention was given to the question of supplying dry steam to the turbine. In the 8 in. supply line, a special low pressure receiver-separator was installed, and between the separator and the turbine throttle there was a length of about 12 ft. of straight piping. In this 12 ft. of piping, made with a 10 in. inside diameter, a coil of 1 in. copper pipe was placed, to which a live steam connection was made at one end and the other end led to a steam trap

Immediately before the low pressure throttle valve of the turbine, a Cochrane multiport flow valve was placed, the purpose of which was to prevent the loss of vacuum in case of failure of the pressure or failure of the exhaust steam supply. The following velocities were used in deciding upon the various pipe sizes: On the low pressure steam supply to the main turbine, 9500 ft. per minute; on the exhaust from the main turbine, 26,000 ft. per minute for the maximum condition and 16,700 ft. per minute for the normal condition; on the water line supplying the condenser 4.6 ft. per second on the discharge line and 3.5 ft. per second on the suction line. The exhaust line from the turbine driving the circulating pipe was figured for a future maximum velocity of 25,700 ft. per minute, and for the present condition, 15,500 ft. per minute.

The turbine is of the combination high and low pressure type and is designed to carry a normal full load of 350 h.p. with 120 lb. steam pressure at the turbine throttle and 3 in. absolute pressure in the turbine wheel case. In order to take care of overloads, the turbine is designed to operate with mixed pressure and, with steam at 3 lb. gage on the low pressure side and 120 lb. on the high pressure side, will carry 600 b.h.p. continuously. It is also designed to carry the full overload of 600 h.p. on high pressure steam only.

The turbine is of the De Laval multistage impulse type containing nine wheels with one row of buckets on each wheel. The turbine shaft operates at a speed of 5000 r.p.m. It is geared to 600 r.p.m. and this shaft in turn is geared to 100 r.p.m., the gears being of the double helical involute type with 45 deg. teeth. The pinion teeth in each case are cut from chrome nickel steel forged bands, the gears being made up of cast iron centers on which are shrunk rolled steel bands. The 600 r.p.m. shaft is supplied with a tachometer having a 4 in. circle with speed indications from 200 to 800 r.p.m. in 300 deg. of the circle. The entire cost of the installation consisting of the turbine, reduction gear, condenser piping, circulating pump, etc., delivered and erected, approximated $25,000. On account of the better economy of the turbine, it has been possible to operate the plant on about 300 boiler h.p. less than before and to effect the saving of approximately $15,000 per year in operation.

This turbine and the turbine at the Calderbank Steel Works in Scotland are the only two installations of their kind in existence.

In the discussion which followed, Jos. Breslove gave some data concerning the Calderbank Steel Works plant and especially the reduction gear used there. The reduction is effected through two gear sets bringing the mill shaft speed down from 2000 r.p.m. to 70 r.p.m. Flexible couplings are fitted between the turbine and the high speed pinion shaft and also between the first and second reduction gears. The low speed gear is keyed directly upon the shaft of the flywheel shaft which carries a 23 ft., 100 ton flywheel, supported between two heavy bearings (25 pp., 7 figs.).

INSTITUTION OF MECHANICAL ENGINEERS

Advance paper C, read February 19, 1915, in London.

CONVERTIBLE COMBUSTION ENGINES, Alan E. L. Chorlton

The author considers the question of design of convertible combustion engines, that is, engines which may be operated without essential alterations, on more than one kind of fuel.

At first sight, one might think that a combustion engine most ready to work on different fuels would be of the self-ignition type, with a cycle approximating to that of constant pressure and the only change necessary in going from liquid to solid fuel would be in the fuel injection device. In practice, however, owing to the difficulty with solid fuel injection, such a type would not prove workable and even when the fuel is first gasified, the results do not justify the complication. The problem of designing a convertible engine is better met by trying to combine known types for gas and oil in which good results are obtained at present and which, in general principles, show the same characteristics.

In the normal engines for both gas and oil, the chief difference lies in the degree of compression. There is no fundamental difference in engines for gaseous or liquid fuels except in their compression cycles, which shows that any schemes of convertibility must provide means whereby the requisite compressions can be obtained, but as there is a great gap between compressions of 100 lb. per sq. in. for a gas producer and 500 lb. in the case of crude oils, the tendency is, for practical uses, to combine the lower compression oil engine and the high compression gas engine and thus deal with a small compression pressure range. The desirable characteristics of a convertible engine are simplicity and reliability, high economy for each fuel, first cost as low as possible above that of the standard engine for each fuel, easy convertibility and as nearly as possible the same power for each fuel. The author divides all types of engines into three groups; first, engines of low compression and low power; second, engines of higher compression and higher power, and third, engines of maximum compression and high power.

Group 1. As an example may be taken the ordinary motor car engine, which has a compression up to 90 lb. per sq. in. and with slight modifications can run on several fuels. It is, however, designed for and works best on gasoline, fairly well but not so economically on city gas, requires very good kerosene and is not efficient at low compression with producer gas. If a more common kerosene or a good quality of crude oil is used, means must be provided whereby more heat is available for the ignition and combustion of the oil which can be done conveniently by the addition of an unjacketed portion to the cylinder end, when the engine becomes of the hot bulb type. Electric ignition is provided for gasoline as well as the kerosene, and good crude oil would be self ignited by the hot bulb. Fig. 7A shows such an engine for

small powers and it can be changed by unskilled labor from a gas engine working with a wood or coal producer to an oil engine, the governor requiring no adjustment for the full range of fuel. This type of engine is not suitable for any comparatively low powers and its range of fuels does not include anything heavier than good crude oil, and even its economy on oil is not high. *Group 2*, engines of higher compression and higher power, is represented by the Diesel engine with compression of over 500 lb. per sq. in. when using tar oils. Since a Diesel engine uses compression far exceeding the maximum compression for gas in a normally

a Engines working with a compression not exceeding 150 lb. for both oil and gas, and which may employ pocket firing with or without air injection for one, and electrical ignition for the other, or some combination, the smaller compression not involving material mechanical change of the parts.

b Engines working with a higher compression for oil than for gas, involving some modification of the combustion chamber by substitution of a part for oil as against a part for gas; otherwise maintaining the simplicity of both types.

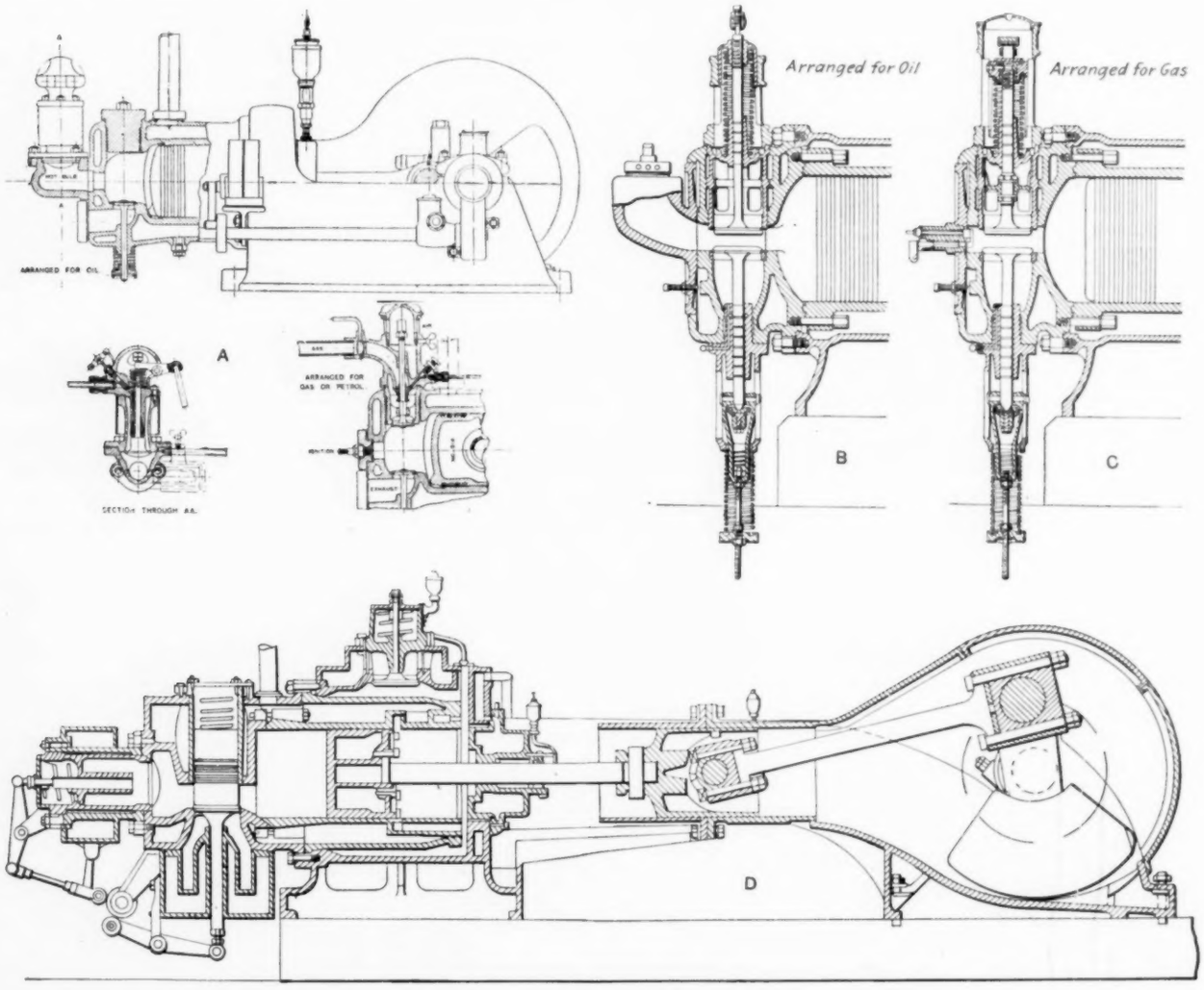


FIG. 7 CONVERTIBLE COMBUSTION ENGINES

used type of engine and in addition requires an expensive high pressure air pump, there is no commercial advantage in working it on gas.

Engines with a moderate compression suitable for developing higher powers, range in compression between 150 and 300 lb., a low range being suitable for most forms of producer gas but not usually exceeded because pre-ignition of the compressed charge is more prevalent in very high compression gas engines.

Group 3. Engines with a moderate compression suitable for developing higher powers. This group may be subdivided into four classes:

c Engines obtaining the necessary change from gas to oil, by temperature control of the air charge, together with alteration of the valve settings.

d Engines employing the super-compression of Dr. Dugald Clerk, to control effectively thereby the compression required for either fuel.

In sub-division *a*, there are a large number of engines which are used only for oil but might, without material alteration, become effective for the use of gas, as for example, a 2-cycle Bolinder engine shown in the original article. In sub-division *b*, the outputs in general figures for the engines on oil and gas appear to be very similar and so are the

diagrams actually taken. The possibilities of this type of convertible engine appear therefore quite great; in fact an engine is being made at the present time in considerable numbers, to fulfill these conditions, (Figs. B and C). In both cases, it presents the ordinary features of the four-cycle, the only change involved in converting from oil to gas being in the combustion bulb of the oil engine in changing from an oil type to a gas type of piston.

As to class *c*, it is mechanically convenient but not quite efficient, as the author attempts to prove. In class *d*, the Clerk super-compression engine is a promising type for dealing with the variable compression problem of the convertible engine. In it, Fig. D, an extra charge of air or inert gas is added to the working mixture at the end of the suction stroke. By this "watering" of the charge much lower maximum flame temperatures are obtained and a higher mean cylinder pressure rendered possible. Further, the compression can be adjusted between wide limits. The conclusion at which the author arrives is that for powers up to say 1000 h.p., engines of the type shown in Fig. B and C are the most suitable as convertible engines while for the larger powers, when tandem engines and size and weight of removable parts become a problem, the Clerk super-compression type offers a hopeful possibility (15 pp., 13 figs.).

The Journal, No. 2, February 1915

The Steady Flow of Steam through a Nozzle or Throttle, Professor H. L. Callendar (abstracted)

Standardization of Pipe Flanges and Flanged Fittings, John Dewrance (abstracted from Advance Paper in *The Journal*, March 1915, p. 189).

ON THE STEADY FLOW OF STEAM THROUGH A NOZZLE OR THROTTLE, Professor H. L. Callendar.

In the course of some experiments on the law of condensation of steam previously undertaken by the author, in which the temperatures of steam during adiabatic expansion and compression were observed with a very sensitive platinum thermometer in the cylinder of a steam engine, it was found that the index m of the adiabatic equation $PV^m = \text{constant}$ was very nearly independent of the pressure and temperature, and equal to 1.30. This result, at first sight, seemed discordant with the wide variations of the specific heat as shown by other experiments made at the same time, but was later on explained by the author's theory. The temperature measurements also showed that during rapid adiabatic expansion, the temperature of steam might fall appreciably below the saturation temperature, indicating a state of supersaturation in the cylinder. The practical importance of this state of supersaturation increases in proportion to the rapidity of the expansion, and becomes considerable in the case of expansion through a nozzle.

The object of this paper is to apply the equation for supersaturated steam to the problem of flow of steam through a nozzle or throttle.

The author objects to the formula commonly employed on various grounds, in particular, because steam cannot condense reversibly in the time taken to reach the throat of the nozzle, and the adiabatic equation for wet steam does not apply, therefore, to the maximum discharge determined by the state in the throat. Dry steam, when cooled by rapid expansion beyond the saturation point, does not condense unless suitable surfaces or nuclei are present to start the condensation, and when issuing from a jet, does not appear cloudy for an appreciable space beyond the throat. It is physically impossible that any material condensation should occur in the time occupied in reaching the throat of the jet, which is generally of the order of 0.0001 second. The adiabatic equation which applies to the discharge, therefore, is not that of wet steam but that of dry steam, superheated or supersaturated. According to the author's equation, the appropriate value of the index m is 1.30, which agrees much better with observations of the discharge than the value 1.135 for wet steam commonly employed. The author points out, however, that it would not be justifiable to use this equation if it had not been shown by theory and experiment that it was thermodynamically consistent:

1. with the characteristic equation
2. with the cooling effect in expansion through a throttle
3. with the variation of the specific heat
4. with the equation of saturation pressure

and claims that the correspondence of his formula in all these cases is thermodynamically exact.

Equations for discharge of superheated or supersaturated steam according to the author's equations, the relation between P and V in the adiabatic expansion of dry steam, whether superheated or supersaturated, is

$$P^n\ (V-b)^{n+1} = \text{constant, or } P\ (V-b)^m = \text{constant,}$$

where $m = 1 + \frac{1}{n} = 1.30$.

The small constant b is the volume of the liquid at low temperatures, namely, 0.0160 cu. ft. per lb. or 0.001 cbm. per kilogram.

The corresponding expression for the total heat, $H = E + aPV$, is

$$H = a(n+1)\ P\ (V-b) + abP + B,$$

where B is a constant having the value 464.0 calories on the Centigrade system, or 835.2 B. t. u. on the Fahrenheit system, and a is the numerical factor reducing PV to heat units.

These equations may be combined with the equation of flow $kUX = WV$, and the thermodynamical relation $\frac{U^2}{2g} = J(H_o - H)$, to determine the maximum discharge in adiabatic flow, in the following manner.

The condition that the flow W is to be a maximum for a given value of the throat section X, or that X is to be a minimum for a given value of W, gives immediately the simple relation,

$$\frac{dU}{dV} = \frac{U}{V}$$

Eliminating $\frac{dU}{dV}$ by differentiating the equation $\frac{U^2}{2g} = J(H_o - H)$, we find

$$\frac{-U^2}{JgV} = \frac{dH}{dV} = a(n+1)P + a(n+1)\ (V-b)\left(\frac{dP}{dV}\right) + ab\left(\frac{dP}{dV}\right)$$

Substituting the value of $\frac{dP}{dV} = \frac{-mP}{V-b}$ from the adiabatic equation, we obtain

$$\frac{U^2}{V^2} = \frac{amJgP}{V-b}$$

which is the exact expression for the velocity of sound in the vapor in the state (P, V), and differs from the expression usually given only by the small quantity b, which is commonly neglected. This term is theoretically required, even

in the case of hydrogen, the most perfect of all known gases, in order to explain the Joule-Thomson heating-effect, which is of great practical importance in the liquefaction of hydrogen. It is also required to explain the limit of compressibility of gases, and the increase of the velocity of sound for intense disturbances. Since, however, b is very small, and its exact value necessarily uncertain, the equation may be reduced to the simpler form,

$$\frac{l^2}{Jg} = amP(V+b)$$

which gives the throat velocity in terms of P and V in the throat.

The primary effect of supersaturation in the throat of a nozzle is to increase the discharge by about 5 per cent as compared with that calculated on the usual theory with a given throat area. The secondary effect is to cause an increase of entropy and volume when the steam becomes wet after passing the throat. The two effects require, for a given throat area and ratio of initial to final pressure, an increase of 6 to 8 per cent in the final area of the cone, or an increase of length of 3 to 4 per cent in the diverging cone for a given angle of divergence.

The effect of friction in the throat is to reduce the discharge by a small fraction, which appears to vary inversely as the initial pressure, and inversely as the throat diameter for similar nozzles. The order of magnitude of this fractional reduction, for a well-designed nozzle with smooth contours, appears to be given by the formula $\frac{1}{P_o D}$, where P_o is the initial pressure in pounds per square inch absolute, and D the diameter of the throat in inches.

The effect of friction beyond the throat increases with increase of velocity and diminution of final pressure, and may be estimated with some degree of probability by taking the percentage loss of heat-drop to be proportional to the heat-drop itself. The diminution of velocity and increase of volume due to friction may require an increase of 10 to 20 per cent in the final area, equivalent to an increase of lengths of 5 to 10 per cent for a given angle of divergence, as compared with the length calculated for the case of frictionless flow.

ROYAL SOCIETY

Proceedings, Ser. A, vol. 91, no. 623, London.

ON THE FLOW OF VISCOUS FLUIDS THROUGH SMOOTH CIRCULAR PIPES, Charles H. Lees

The article discusses the problem of the flow of a viscous fluid through tubes of circular section, especially smooth tubes, and in the introduction gives a review of the work previously done in this connection.

The Principle of Dynamical Similarity shows that for the flow of viscous fluids through pipes, if for a number of cases $\frac{vd}{\nu}$ has the same value (where v is the speed, d the diameter of the pipe and ν the kinematical velocity), then for the same cases $\frac{R}{\rho v^2}$ will have the same value, where R is the resistance per unit surface of contact of fluid and pipe, and ρ the density. Hence, if $\frac{vd}{\nu}$ be taken as the abscissae and R as the ordinates, every case of motion of a viscous fluid through a pipe will be represented by a point of the diagram and all of the points will lie on a curve, if the principle is strictly applicable to such cases, or will cover a strip, the width of which will increase as the applicability of the principle decreases. The observations made by Stanton and Pannell on the flow of air and water through pipes show that if v, the velocity, be taken as the mean velocity over the whole section of pipe, the locus of the points in the diagram is a narrower strip, the width of which is only of the order of the errors of experiment and that for cases in which $\frac{vd}{\nu}$ is the same, the law of distribution of velocity over the cross section is the same. The author proceeds to the determination of the simplest form of the function φ in $R/\rho v^2 = \varphi(vd/\nu)$ which would embody the results of Stanton and Pannell on one side and of Saph and Schoder on the other side. He obtains the following expression

$$R/\rho v^2 = 0.0009 + 0.0765\ (v\ d/\nu)^{-0.25}$$

or

$$R = \rho v^2\ [0.0765\ (\nu/vd)^{0.25} + 0.0009] = \rho\ [0.0765\ (\nu/d)^{1.65}\ v^{1.65} + 0.0009\ v^2]$$

and since this expression satisfies the principle of similarity, it has been shown to hold for the mean speed of flow of air and water through pipes of diameters between 0.3 and 12 cm. The constants of the above equation hold over the whole of this range at least, and probably this type of relation with a small change of the constants will apply over a much wider range. The author proceeds to the development of a formula expressing not R, the resistance per unit area of surface exposed to the fluid, but the fall of pressure $p_o - p_1$ along a given length l due to it, by reproducing, side by side, the observations of Stanton and Pannell with a line showing the values deduced from his expressions and shows the close agreement between the two. The form of the final expression for the fall of pressure along the tube indicates that this fall will, for all velocities, be approximately proportional to the power of the velocity between the 1.65th power and the square, and that as the speed of diameter increases or the kinematic velocity decreases, the law of variation will approximate more and more closely to the second power. The further conclusions arrived at, are summarized by the author as follows:

a The difference of pressure $p_o - p_1$ in dynes per square cm. between two sections distant 1 cm. from each other along a pipe of diameter d cm. through which a fluid, whose density ρ may be considered constant over the length l and whose kinematical viscosity is ν, is flowing with mean velocity v, cannot be represented by a single power of the velocity but requires for its expression a formula of the type

$$p_o - p_1 = l\rho\ v^2/d)\ (a - b\ (\nu/vd)^n)$$

where a, b, and n are constants.

b To the extent to which the Principle of Dynamical Similarity is applicable to the flow of fluid in tubes, a, b, and n should be absolute constants applicable to all fluids and all tubes. Stanton and Pannell's results show that over a wide range $a = 0.0018$, $b = 0.153$ and $n = 0.35$

c As the velocity and diameter increase and as the kinematical viscosity decreases, the pressure difference varies more nearly as $l\rho v^2/d$.

d The effect of temperature on the pressure difference decreases as the velocity and diameter increase and as the kinematical viscosity decreases. (8 pp., 1 fig. *t.*)

MEETINGS

MINNESOTA, FEBRUARY 12

The regular February meeting of the Minnesota Section was held in the offices of the St. Paul Gas Light Company at which Professor Stewart of the Minnesota Agricultural College gave a talk on Triangulation. He showed a number of slides which illustrated some work on Triangulation which he had done for the Government in some of the western states a few years ago.

ST. LOUIS, FEBRUARY 16

At a meeting of the St. Louis Section on February 16, a Committee was appointed to draw up a tribute to the late Col. Meier which is presented herewith:

In the death of Col. E. D. Meier, the local section of the Am. Soc. M. E. has lost a staunch supporter, adviser and friend.

Although the later years of his life were spent in New York he was a personal friend of many of us and admired by all for in him was combined a charming personality and rare technical ability.

He was a man of great originality and tireless energy, sparing not himself in the promotion of either his own ideas or those of others if he believed them good.

It was largely through his efforts that the local section idea was adopted. To him were due many improvements in his own particular field. Practically to him alone is due the inauguration of the most important movement ever undertaken by the American Society of Mechanical Engineers—the Uniform Boiler Code. If adopted this will do more than any other has done to promote safety from boiler explosions and the consequent conservation of life and property.

We have lost a valued friend, the country a good citizen and the profession an able engineer.

Respectfully submitted,

E. L. OHLE,
E. R. FISH,
EDW. FLAD,
Committee.

BUFFALO, FEBRUARY 25

At a meeting of the Buffalo Engineering Society on February 25, which the members of the Employers Association, the Chamber of Commerce and other Industrial Associations of Buffalo had been invited to attend, M. W. Alexander of the General Electric Company spoke on The Waste in Hiring and Discharging Employees. A very interesting statement that he made after working out the figures on the blackboard showed that in an average of thirteen plants, where 8000 employees had been added to the payroll during the year, over forty-six thousand had been hired and discharged in obtaining the increase of 8000. Based on a very conservative allowance, Mr. Alexander claimed that in the neighborhood of 26,000 of the total number hired were unnecessary, and that the cost of hiring and discharging this 26,000 amounted to over $880,000. After presenting these figures, he gave a very complete explanation of the ideas which have occurred to him in studying this problem, which he has carefully worked out to avoid a considerable amount of this waste.

CINCINNATI, FEBRUARY 25

On the evening of February 25, the members of the Cincinnati Section gave a dinner in honor of Calvin W. Rice, Secretary of the Society. Following the dinner, Mr. Rice was introduced to the joint meeting of the Cincinnati Section and of the Engineers' Club of Cincinnati, to whom he made an address describing the trip of the Society to Germany in the summer of 1913. Mr. Rice began by recounting the very careful preparations that were made for this trip. Before beginning the journey, members were furnished with itineraries giving a complete description of the various places of interest they were to visit. So painstaking was the preparation that members of the party knew not only the hotel for which accommodations were provided for them, but even the numbers of the rooms to be occupied. Mr. Rice described the life on board the ship, the meeting of the reception committee before European shores had been reached, the reception in Hamburg and a series of entertainments given by the engineers of Hamburg, Leipzig, Cologne, Düsseldorf and other cities. He described in detail some of the more remarkable establishments visited, illustrating their principal features by lantern slides.

BOSTON, FEBRUARY 26

A joint meeting of The American Society of Mechanical Engineers, American Institute of Electrical Engineers and Boston Society of Civil Engineers was held at Wentworth Institute, Friday evening, February 26.

Wentworth Institute was founded 3½ years ago for training workmen of the most competent and expert type, foremen and master mechanics, and has grown so rapidly that there are nearly 1300 pupils enrolled in its day and evening classes. This meeting gave an opportunity for the inspection of the new shops and laboratories which are admirably adapted to the special purposes of instruction for which they were planned, with most complete equipment. After a buffet supper the audience gathered in the assembly hall for the formal program upon the general subjects of the training and education of employees and the relation of the employer to his men and their education. There were over 200 present at the meeting and the addresses of all the speakers were very much appreciated. The several papers were as follows: The Responsibility of the Manufacturer for Training of Foremen and Skilled Workmen, by Walter C. Fish, general manager Lynn Works, General Electric Co.; The Employer's Side of the Problems of Irregular Employment, Henry S. Dennison, treasurer, Dennison Manufacturing Co.; Coöperation Between Employers and the Schools, William B. Hunter, director of Fitchburg Industrial School; The Economic Relation Between the Supply of Skilled and Intelligent Workmen and Unemployment of the Masses, Prof. Thomas N. Carver of Harvard University. It is expected to publish an account of these papers in a later issue.

NEW YORK, MARCH 9

At the monthly meeting of the Society in New York held on March 9, Dr. Hollis Godfrey, President of the Drexel Institute of Philadelphia, presented an address on the Application of Engineering Methods to the Problems of the Executive, Director and Trustee. Dr. Godfrey, who has served in his experience two municipalities, and a number of corporations having a large number of employees, has found that it is very necessary to be explicit, and to put various problems in writing so that the Board of Trustees or Managers could determine at a glance how to proceed. He has had to select the facts which were to be studied and after collecting and studying them, to translate them and

lastly to express them in such fashion that the executive can use them effectively for the different purposes for which an executive needs to use such material. Dr. Godfrey considers that it is peculiarly the duty of a consulting engineer concerned with facts to present them clearly and briefly in the three cases, in the case of the presentation to the board, in the case of the education of the staff and in the case of the education of the public.

Dr. Godfrey illustrated his paper with charts which showed graphically the problems with which he has had to deal and the results that he has obtained. A very interesting and lively discussion followed the presentation of the paper.

BUFFALO, MARCH 11

A meeting of the Buffalo Engineering Society was held on March 11. The meeting was addressed by Prof. C. F. Hirshfeld of Detroit on Interesting Features Involved in the Design of the Connors Creek Plant of The Edison Illuminating Company of Detroit. Lantern slides were used to show the geographical outline of the city of Detroit upon which the general distribution of power was indicated by the location of the sub-stations and the reasons explained for locating the new power plant at Connors Creek. Various views were also shown of the location of the plant and of the plant itself at the various stages of construction. The views were also shown giving a cross-section outline of the boiler house, turbine room and electrical power unit and a full explanation was given on the operating of the various parts of this machinery, which showed that a careful estimate has been made covering every detail of the power generation and consumption. All this has probably been worked out in more detail than any other plant which has been built in this country, and consequently the overall thermal efficiency of the plant as a unit is expected to equal if not to exceed any similar power plant which has ever been built.

About 150 members were present at the meeting and a large number of them entered into a discussion of Professor Hirshfeld's paper.

CINCINNATI, MARCH 18

A joint meeting of the Cincinnati Section of The American Society of Mechanical Engineers and of the Engineers' Club of Cincinnati was held on March 18. Theodore H. Schoepf, of the Westinghouse Company, gave an address on The Electric Commercial Vehicle. The speaker confined his remarks entirely to electric trucks. He began by describing the conventional design of the electric truck, and illustrated by slides the position of the battery box, the motor, the gearing of the latter, the steering gear, and the location of the brakes. He stated that the 1000 lb. and 4000 lb. trucks were the most popular, and that the use of such trucks was growing by leaps and bounds. After showing by various views and line drawings, the conventional design of the electric truck, some interesting departures from the conventional design were illustrated and discussed. A balanced-drive truck, in which gears are contained within wheels with solid webs and the entire motor and differential are contained in a hollow cast rear axle, was given considerable attention.

The speaker dwelt at length on the economy attending the use of electric trucks, quoting liberally from statistics tabulated in Chicago, Boston and New York. The range of speeds and distances per day within which the electric truck is most effective were discussed, the speaker admitting that, beyond a certain range, the electric vehicle could not compete with the oil-driven machine. He concluded his address with descriptions of some of the motors used on electric vehicles, which motors ranged from 70 to 90 lb. h.p. and had a great overload capacity, a maximum efficiency of between 85 and 90 per cent and a long range of high efficiency.

NECROLOGY

WILLIAM ALEXANDER CHERRY, JR.

William Alexander Cherry, Jr., was born in Denver, Colorado, in October, 1888, and was graduated from Columbia University in 1911. During the summer of 1909 he served a machine shop apprenticeship with the Acme Machine Company of New York and a power plant apprenticeship with the New Rochelle Light and Power Company of New Rochelle during the summer of 1910. After his graduation from Columbia he became associated with Viele, Blackwell and Buck, of New York, Consulting Engineers. While with them he worked on several designs such as hydraulic power stations and machines for a new Gas Producer. He was also employed in the laboratory on the practical end of the above process in testing out various materials to be used in the manufacture of producer gas.

For the past two years Mr. Cherry has been connected with the Florida Abstract and Title Insurance Company of Jacksonville, Florida. He died in Atlanta, Ga., on March 6.

HENRY G. MORRIS

Henry G. Morris was born in Philadelphia May 25, 1839 and graduated from Haverford College. He engaged in active manufacturing business in early life, and when still a very young man was a member of the celebrated firm of Morris, Tasker & Co., who were the first manufacturers of wrought iron pipes and boiler flues. A few years later he became the sole owner of the Southwark Foundry, where some of the largest blowing engines, pumps and other heavy machinery were constructed, and at that time was justly regarded as one of Philadelphia's greatest captains of industry. Mr. Morris was one of the first Directors of the Pennsylvania Steel Company, and was one of the few men in this country, like Alexander Lyman Holley, to recognize the importance and value of the Bessemer process. He was a leader in the design and manufacture of the most diversified kinds of machinery used on sugar plantations and in refineries, gas plants and water works, and among the first in this country to recognize the value of compound engines in marine engineering.

He early became interested in electrical engineering, and will undoubtedly be best remembered in connection with Mr. Salom in the invention and development of the Electric Vehicle for which, twenty years ago, they received the gold medal of the "Times-Herald" Motocycle contest in Chicago, 1895 (the birth of the automobile), and the John Scott Legacy Medal of the Franklin Institute, Philadelphia. He took out numerous patents in connection with the same and for storage batteries.

He was a member of many national societies and associations, including the American Society of Mechanical Engineers, of which he was a past vice-president; The Engineers

Club of Philadelphia, of which he was a past president; The American Institute of Mining Engineers, The American Society of Civil Engineers, The Franklin Institute of Philadelphia, and the Union League of Philadelphia, of which he was the oldest living member in point of time with a single exception. He was elected a member February 14, 1863. Mr. Morris died on January 19.

FREDERICK WINSLOW TAYLOR

Frederick Winslow Taylor, Past-President of The American Society of Mechanical Engineers, died in Philadelphia on March 21. He was born in Germantown, Philadelphia, in 1856. His primary education was obtained in this country and in France and Germany. By night study he secured the degree of Mechanical Engineer from Stevens Institute of Technology.

He served apprenticeships in pattern making and at the machinist's trade in Philadelphia, and began practical work in the shops of the Midvale Steel Company in Philadelphia, where in six years he worked up to the position of chief engineer. Beginning here and continuing later at the works of the Bethlehem Steel Company, he made a scientific study of labor problems and efficiency and put into operation principles of scientific management which have since received world wide attention and application in many industrial organizations. Incidentally, this work led to the study extending over a period of 26 years of the laws of cutting metals; and the development of the Taylor-White process for the heat treatment of steel for cutting tools.

A more complete account of his life, with appreciations of his career, appear in another part of this issue of The Journal.

PERSONALS

Louis M. Zach has become associated with the engineering department of the Anaconda Copper Co., Anaconda, Mont. He was until recently mechanical engineer with the Doe Run Lead Co., Rivermines, Mo.

Thomas A. Bennett, who for the past five years has had charge of the conveyor and elevator belt sales of the B. F. Goodrich Co., Akron, O., has severed his connection with that company and has become the assistant to the general sales manager of the New Jersey Zinc Co., with offices in New York City.

Stephen G. Luther is now connected with the alkali division of the Philadelphia Rubber Works Co., in Akron, O., as manager of the experimental department. He was formerly located at the Philadelphia factory of the company.

J. E. Woodwell announces the dissolution of his partnership with L. B. Marks and will locate at 8 W. 40th St. about May 1, where he will continue the general practice of consulting engineering.

Clarence M. Davison has resigned his position as assistant chief engineer of the Kennedy Stroh Corporation, Oakmont, Pa., and has accepted the position of general manager of the Westbrook Elevator Company, Danville, Va.

Louis T. Sieka has resigned his position as mechanical superintendent of the Tooele Plant of the International Smelting Company, Tooele, Utah, and has accepted the position of mechanical superintendent and engineer for the St. Joseph Lead Co., Bonne Terre, Mo.

Wm. F. Gillies has become manager of the Ingersoll-Rand Co., Pittsburgh, Pa. He was until recently New York branch manager of the A. S. Cameron Steam Pump Co.

Joseph L. Gilson has severed his connections with the De La Vergne Machine Co. of New York, and has accepted a position with the Arctic Ice Machine Co., Canton, O.

Henry R. Towne has retired as president of the Yale & Towne Manufacturing Company, a position which he held for 46 years, and has been elected chairman of the board of directors. To fill the vacancy created by Mr. Towne's partial retirement from the activities of the company, the directors have elected as president, Walter C. Allen, until recently vice-president and general manager of the company.

Frederick Ray has recently opened an office at 50 Church St., New York, as Consulting Engineer, where he will make a specialty of centrifugal pumping machinery, condensing equipment, cooling towers and similar apparatus.

Charles H. Schmalz is manager of the Billings Foundry and Manufacturing Co., Billings, Mont. He was formerly associated with the Boston and Montana Reduction Department of the Anaconda Copper Mining Co., Great Falls, Mont., as assistant master mechanic.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

A meeting of the Student Branch of Armour Institute of Technology was held on March 11 at which the following officers were elected: G. F. Gebhardt, honorary chairman; J. M. Byanskas, president; B. S. Carr, vice-president; E. S. Echlin, secretary; L. Luckow, treasurer.

G. F. Wetzel, '12, read a paper on paints used on engineering work. The paper contained a description of the constituents of the paints used on structural work and similar engineering work. Formerly it was taken for granted that any kind of paint would do, but now large buyers test paint submitted before purchasing. In government work, the paint has to conform to the standard formulæ worked out in the testing department.

BROOKLYN POLYTECHNIC INSTITUTE

The Polytechnic Institute of Brooklyn Student Section held its regular monthly meeting on March 6, at which Dr. Magnus C. Ihlseng, consulting professor of Works Engineering at the Polytechnic Institute, gave an illustrated talk on Coal Mining. The speaker outlined the methods pursued in mining, the ventilation safety methods and the costs of the different grades of coal.

V. N. Hewlett, a student, read a paper on Modern High Speed Automobile Motors, showing the progress made since 1907 in automobile motor design, with special reference to the different types of valves which have been perfected.

Since January 15, excursions have been made to the following places of interest: January 16, Hecker-Jones-Jewell Milling Company, New York City; February 20, Nicholas Power Company, manufacturers of moving picture machines, New York City; February 27, Morse Drydock and Repair Company, South Brooklyn; March 6, Power Station of the New York Central Railroad at Port Morris.

During the spring vacation of the Institute, an inspection trip will be undertaken by members of the Branch, including the cities of Cleveland, Detroit, Chicago, Cincinnati and Pittsburgh.

At this meeting the resignation of the secretary of the Branch, Samuel Kobre, was accepted and George A. Wieber was elected to take his place for the remainder of the present year.

CARNEGIE INSTITUTE OF TECHNOLOGY

The regular meeting of the Carnegie Student Branch of The Am. Soc. M. E. was held at Machinery Hall on February 10. W. C. Stevenson, C.I.T. '08, read a paper on The Mechanical Engineering Involved in Erecting an Electrically Driven Bar Mill, at the Duquesne Works of the Carnegie Steel Company. He gave a detailed account of many of the problems which had been solved in the erection of this mill,

and described its peculiar features. For instance, the rolling of the bar is entirely automatic, no catchers being used. Mr. Stevenson illustrated his talk with the blue prints which had been used in the construction of the mill. The paper was discussed by Professor Trinks.

COLORADO AGRICULTURAL COLLEGE

At a meeting of Colorado Agricultural College Student Branch on February 17, the article by F. R. Low in the October issue of The Journal on Pulverized Coal for Steam Making, was reviewed by T. H. Sackett. His talk brought out the economical use of pulverized coal as compared with lump coal. This was followed by a general discussion.

Mr. Murray gave an interesting talk on Safe Steel Rails, and placed emphasis on the numerous tests made to determine flaws and the method of eliminating them.

At a meeting on February 26, Large Steam Power Plants was the subject of an instructive talk by Mr. G. G. Law. His subject covered the work in the whole plant, but more especially the boiler room and the new appliances used there. At the close of the paper Mr. Law answered several questions on his subject.

Mr. Morrison discussed the paper on Industrial Service in Engineering Schools by J. W. Roe, which appeared in the June issue of The Journal. He gave a history of the work and then spoke of the problem of Americanizing the laboring immigrant. Professor Crain spoke briefly on the same subject, comparing the ordinary reform methods with those in the line of industrial reforms. He brought out clearly the practical side of the subject and showed how the men could help to solve the problems of capital and labor. Mr. Stephens discussed briefly the subject of Industrial Service Work which he himself had seen in Chicago.

KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College Student Branch on February 4, E. Lee Heidenreich, a consulting engineer of Kansas City, Mo., addressed the Branch on Reinforced Concrete in some Engineering Branches. Mr. Heidenreich gave a short history of the use of concrete, especially the Monier construction or, as it is now known, reinforced concrete. The speaker advocated a more extensive use of concrete in all types of construction, its greatest value being that it is almost fire and water proof. Mr. Heidenreich discussed the use of reinforcing and some of the advantages and disadvantages of the forms now in use. He personally preferred steel of high elastic limit from 50,000 to 55,000 lb. per sq. in., avoiding twisted square bars and using bars with the deformations at right angles to the axis of the bar.

On March 4, H. R. Setz, a member of The Society and Chief Engineer of the Fulton Iron Works, St. Louis, gave an illustrated lecture on the Development of the Diesel Engine. Mr. Setz has had experience in Europe with the earlier types of Diesel Engines. He very clearly pointed out defects in the first non-jacketed types and also the impracticability of using the same valve for controlling the inlet and exhaust events. By means of original diagrams he illustrated the difference in temperature between the actual Diesel diagram an dthe ideal Diesel engine.

KANSAS UNIVERSITY

The regular weekly meeting of the Kansas University Student Branch was held on February 25, at the home of Dean P. F. Walker. Floyd Nutting gave a description of the water-power development at Keokuk, Iowa. Mr. Nutting visited this plant in November 1914, and spoke chiefly from notes taken at that time. After describing the dam and power house equipment, he spoke of the service and transmission lines with particular reference to the power furnished the city of St. Louis. He also gave some ideas of the size and construction of the government locks at the Keokuk dam.

B. O. Bower spoke on the Kansas City Automobile Show, which was held February 8 to 14, 1915. He told of the tendencies in design which 1915 cars are following, and compared in some detail the motor part proportions of the new cars with those of earlier models and explained the reasons for the changes.

LELAND STANFORD UNIVERSITY

At a meeting of the Leland Stanford Mechanical Engineering Association on February 9, the resignation of H. M. Henderson as secretary of the Branch was accepted, and C. L. Addleman was elected to fill the vacancy.

Prof. W. F. Durand addressed the society on ways of making the meetings for the present semester a success. An illustrated talk on Automobile Foundry Work was given by B. M. Green, President of the Branch. The speaker laid emphasis on the arrangement of molds and conveyors in the modern shop. The slides showed the Ford foundry and a large jobbing foundry.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On February 24, at a meeting of the Massachusetts Institute of Technology Student Branch, Mr. Gillespie of the United Shoe Machinery Company of Beverly, Mass., gave a very interesting talk, illustrated by moving pictures, on From Pelt to Welt, in which he took up the complete process of making Goodyear welt shoes. Mr. Gillespie gave the history of the shoe as one of the garments of man and traced its development from 4000 B.C. to the present time. He showed pictures of many of the old types of shoes, and compared some of the very earliest shoes with the shoes now worn by the Mexican army, showing the close resemblance. The speaker also told of the development of the royalty system used by the United Shoe Machinery Company today, and showed pictures of some of the company's welfare work.

OHIO STATE UNIVERSITY

On February 27, Calvin W. Rice, Secretary of The Society, addressed the members of the Ohio State University Student Branch on the 1913 Trip of the Am. Soc. M. E. to Germany. Before touching this subject, however, Mr. Rice spoke briefly of The Engineering Foundation, the coming meetings of the Society, The International Engineering Congress, and The Pan American Congress to be held in Washington. The excellent library facilities which the Society offers to its members were mentioned, also the purpose and object of the Student Branches was reviewed.

In speaking of the future of the engineering profession, Mr. Rice stated that it was certain to supplant the influence of the lawyers and doctors as leaders of men; and that the future engineer would cease to deal with things entirely and would deal more and more with men and would thereby become more prominent in politics and in the progress of established communities. Mr. Rice pointed out the extreme difficulty the United States was having and would have in maintaining her neutrality, and advocated the establishment of a civilian engineering reserve corps to assist the work of the war department in the defense of our coast cities.

The talk on the 1913 trip of the Society to Germany was illustrated by numerous excellent lantern slides, which impressed one with the wonderful organization of the German nation, the sincere and genuine hospitality which it extended to the American visitors and also with the high public esteem which the engineering profession there enjoys.

PENNSYLVANIA STATE COLLEGE

The new officers of the Pennsylvania Student Branch were installed at a meeting on February 12. William Blume read a paper on the Diesel Engine, giving an interesting and detailed account of the construction, operation and characteristics of the Diesel Engine together with a biographical sketch of Rudolf Diesel.

On March 4, there was a special literary meeting. A paper on the Keeler Boiler was read and illustrated with stereopticon slides which were furnished by the Eugene Keeler Company.

PURDUE UNIVERSITY

At a meeting of the Student Branch of Purdue University on February 9, the following officers were elected for the

second semester: B. J. Davidson, chairman; R. T. Gray, vice-chairman; O. F. Hambrock, recording secretary; V. P. Craig, corresponding secretary; J. M. Lonn, treasurer. J. W. Trimmer, '15, gave an illustrated lecture on Air Brakes.

At a meeting of this Branch on February 23, E. G. Stradling, signal engineer with the Monon Railroad, gave a paper on Signal Engineering and Apparatus. He said that the art of signaling as applied to steam and electric railways is divided into two general classes. These are known as interlocking signaling and block signaling. As the word implies, the term interlocking when applied to signaling means that certain switches and signals are so inter-connected with one another, that they must be operated in a pre-determined sequence. Interlocking is used for the protection of trains in their movements at railroad crossings at junction points and at points where there are several switches used by a large passenger terminal. The well known term of block signaling means that a railroad between certain points is divided into short sections of a desired length, each section known as a block and the entrance of a train into each block is regulated by a signal of some design.

Today for a simple crossing of two single tracks, we have on each track approaching the crossing a derail located in most cases five hundred feet from the crossing. Fifty-five feet beyond this is located the home or positive stop signal and farther out some three or four thousand feet is located the distant or caution signal. All of the derails with their locks and all of the signals are controlled by levers grouped together in a tower near the crossing. These levers are controlled by one man and are all normally placed in the position which has all derails set against traffic and all signals set so as to stop all trains. The levers which control these respective functions of the plant are so connected mechanically that not any one of the caution signals can be moved to the proceed indication for a train until its respective home signal has first been moved to the proceed position. Neither can the home signal give the proceed indication until both the derails on that track have been set and locked for the passage of the trains, and with the first movement of the levers that set the derails for a passage of the train on that track, the derail levers for the other track are locked in their normal position so that neither they nor the signal on that track can be moved but must remain in a position to oppose traffic. From this simple plant with its twelve or fourteen levers, one can go to the plant in some of the new passenger terminals, one of which has over four hundred levers.

Block signaling as defined by the Inter-state Commerce Commission consists of a scheme for maintaining a space interval between trains as distinguished from the train rule system of attempting to maintain a time interval. This can be accomplished either by a manual block system or an automatic block system. The manual block system which was first introduced on the American railways in about the year 1863, requires the coöperation of two men for each block, generally telegraph operators, one of whom notifies the other when a train enters the block while the second notifies the first as soon as the train has passed out, so that the first operator may permit a second train to enter.

In the year 1879, the track circuit was introduced and thus began the development of the automatic block signal system. The track circuit consists of a source of electric energy, usually a primary battery connected one pole to each of the two rails of the track, using the rails as conductors and of a relay connected between the rails at the outer end of the circuit. The presence of a train on the rails will shut the circuit and open the relay, likewise any interruption to the circuit from a broken rail or open switch will cause the relay to open. By the control of the secondary circuit through this relay, it is possible to operate the block signals in any manner that may be desired.

STEVENS INSTITUTE OF TECHNOLOGY

On Wednesday, February 17, the Student Branch of The Am. Soc. M. E. of Stevens Institute of Technology conducted an inspection trip to the Crucible Steel Company, in Harrison, N. J. The party was made up of about twenty students who were guided through the plant and shown the three processes employed by the company in the manufacture of chrome, nickel and tungsten steels: the open hearth, the electric furnace and the crucible methods.

The following Wednesday, the Stevens Engineering Society visited the Keuffel and Esser factory in Hoboken to see the manufacture of drafting and surveying instruments. The trip through the plant was very instructive, but the party was prohibited from inspecting the secret processes, such as the graduation of the Keuffel and Esser slide-rule. The periscope which was being constructed in the factory at the time of the trip was of particular interest because of the recent German submarine raids on the English coast.

On Friday of the same week, Charles H. Day of the Aircraft Company, at Bound Brook, N. J., gave a further insight into machines of war, by a lecture on the Engineering Principles of Aeronautics. Mr. Day, who has had much experience in the building and flying of aeroplanes, was in an advantageous position to talk from the birdman's point of view. The most remarkable of his statements was that about nine out of every ten flying machines built in the United States have been built without a stress diagram.

UNIVERSITY OF CALIFORNIA

At a meeting of the Student Branch of the University of California, A. C. Moorhead gave a paper on State Liability and Compensation Insurance. The paper was discussed by Prof. R. S. Tour, Rene Guillon, H. L. McLean and Robert Christy.

H. L. McLean read a paper on Valuation of Public Utilities. It was discussed by Professor Tour, Rene Guillon, Charles Ball, A. C. Moorhead and Robert Christy.

UNIVERSITY OF CINCINNATI

There was a meeting of the University of Cincinnati Student Branch on February 24. The speaker of the evening, Prof. C. A. Joerger of the Mechanical Engineering Department, gave a paper on Present Day Problems and Tendencies. Professor Joerger called attention to the modern tendency to consider all men equal. The speaker held that this is a false ideal, and that men, rich and poor alike, should be judged by their inherent worth. Respect should be equal, but not the reward. It was pointed out that the tendency is to suppress individual initiative, and that this results in placing incompetent men in positions of responsibility. As corollary to the foregoing tendency, the speaker further emphasized the inclination to disregard experience and authority. His paper was received with great interest, and his conclusions met with general approval.

On February 25, Calvin W. Rice, Secretary of the Society, spoke to the student body on The Advantages of Membership in the Student Branch of the Society. Mr. Rice pointed out that the Society is of great help to engineering students, whether in the mechanical, electrical or civil department. He showed that through The Journal, the Society was furnishing at cost to the students a large body of data on all phases of engineering and was giving them the benefit gratuitously of research work carried on by the special staff of The Am. Soc. M. E.

Mr. Rice gave a lecture illustrated by stereopticon views on the visit of a delegation of the Society to the engineers of Germany. The German Government had one of their best engineers visit this country in advance of the date upon which the American delegation was to sail. This engineer after his return to Germany devoted his time and energy to preparation for the entertainment of the visitors. As a result, all arrangements for traveling, lodging, and sight seeing had been worked out to the smallest detail, and though all the principal cities and engineering works were visited, there was no hitch in the program and there were none of the numerous petty annoyances to which travelers are usually subjected. In every city, the visitors were received with great courtesy by the Mayor (always an engineer) and in many instances they were entertained by the highest officials. Everywhere the delegation was impressed with the remarkable efficiency of the German industrial organization.

UNIVERSITY OF COLORADO

At the meeting of the Colorado Branch on February 25, a paper on Mechanics of Mining was presented by Frank E. Shepard of the Denver Engineering Works. He dealt with the process of mining from the mine to the smelter, taking up the machinery used and its development. With his experiences in the manufacture of mining machinery, he gave descriptions of the various types used for the different purposes. He said that an electric drill which used 1¼ h.p. had lately been developed, but that type of drive had not made the progress it should have made owing to the class of men called upon to handle it. The speaker showed that hoisting machinery is not a simple arrangement because of various attachments and combinations which introduce many complicated problems. The many ways of solving these questions were shown by means of sketches on the blackboard and were extremely interesting. The ore must be crushed in all sizes to free it from the gangue and make the mineral obtainable in a very finely powdered state. This crushing must be done in stages and many different kinds of crushers are in use. After crushing, the cyanide process is used to leach out many of the values. In some cases, the slime flotation method and in others the various types of concentration tables are used. The coöperation of all the branches of engineering are needed, thus requiring many men in one company to produce the results. Mr. Shepard further emphasized the importance of not discarding apparatus and machinery without a thorough trial under working conditions.

On March 11, Charles Hall of the Mine and Smelter Company, Denver, gave a short but interesting talk on Centrifugal and Triplex Pumps. He went into the conditions and arrangement of pumping machinery on different jobs, and mentioned the data needed in order to figure on various cases. Centrifugal pumps will carry about 30 per cent overload.

UNIVERSITY OF KANSAS

A feature with the Student Section of the University of Kansas which is unique among all the student sections of The American Society of Mechanical Engineers is the plan of holding an annual meeting with morning and afternoon sessions, a dinner and speech making in the evening.

The sixth annual meeting was held on February 18 and was largely attended. A series of meritorious papers was presented, several of which it is hoped to publish in abstract in future numbers of The Journal. The morning and afternoon sessions were unusually interesting and contained papers as listed below. In the evening 125 attended the banquet. The papers presented were as follows:

THE RELATION OF TECHNICALLY TRAINED MEN TO THE INDUSTRIES, by Walter Rautenstrauch, professor of mechanical engineering at Columbia University, New York. This paper considered in detail some of the fields of service for the engineer and indicated what practice in these fields involved.

INTERNAL COMBUSTION MOTORS, especially the oil engine type, with special reference to the pumping service in the oil fields, by S. A. Sulentic, chief engineer of the Prairie Pipe Line Co., Independence, Kan.

RATE MAKING IN PUBLIC UTILITIES, by Geo. C. Shaad. This paper dealt with the different types of service charges, including a consideration of intangible values and readiness-to-serve as elements in the problem.

SOME PHASES OF CEMENT MANUFACTURING, by C. A. Swiggett, assistant superintendent of the Iola Portland Cement Co.

MANUFACTURE OF GASOLINE FROM NATURAL GAS, by Louis Bendit, consulting engineer, Kansas City, Mo.

HEATING AND VENTILATING APPARATUS, by H. B. Kraft, of the Kansas City branch of the American Radiator Co.

THE RESULTS OF ORIFICE TESTS CONDUCTED AT JOPLIN, MO., by Ernest O. Hickstein, engineer with the Wichita Natural Gas Co. This investigation dealt very fully with the conditions of air flowing through orifices and was an important investigation in the field of gas engineering. In conducting these tests, a gas holder of 250,000 cu. ft. capacity was used.

SERVICE EQUIPMENT OF THE HARRIS TRUST BUILDING IN CHICAGO, by I. W. Clark, student member.

ENGINEERING PROBLEMS ARISING IN THE TRANSPORTATION OF NATURAL GAS, by Jas. P. Fisher, chief engineer of the Wichita Natural Gas Co.

Prof. Walter Rautenstrauch of Columbia University, New York, who presented one of the papers, has kindly sent the following communication giving his impressions of this meeting:

"It was my pleasure to be the guest of the Student Branch of the A.S.M.E. of the University of Kansas at its Sixth Annual Meeting held Thursday, February 18, 1915, at Lawrence, Kansas. I was so favorably impressed with the work of this branch of the Society that I feel it would be well for each member of the Society to know how excellent a meeting of this sort may be. I, therefore, beg to submit to you an account of this meeting for publication in The Journal. The program which I enclose herewith contains a series of papers representing broad fields of activity of Mechanical Engineering and each one was presented in an interesting and instructive manner. The last two papers on the Flow of Air Through Orifices, by Mr. E. O. Hickstein, and Engineering Problems in the Transportation of Natural Gases, by Mr. James P. Fisher, were of a standard commensurate with those presented to the Society at its annual meetings. The students showed a real interest in each one of the papers presented and the whole meeting seemed to create a very deep impression on the minds of the students. The evening was devoted to a banquet at the principal hotel in Lawrence, at which about 125 members were present. A number of addresses were made at this banquet and a very pleasant evening was had by all those present. Great credit is due to Dean P. F. Walker for the manner in which he has conducted these annual meetings and it is believed that the work of this student branch may well be a model to all student branches throughout the country. It has occurred to me in this connection that a great benefit would result if there should be appointed a set day in the year to be known as the annual meetings of student sections of the A.S.M.E., at which time the whole day should be turned over to the presentation of papers such as is being done at the University of Kansas. It is felt that a definiteness would be given to the purpose of this work which would result in considerable benefit to the Society."

UNIVERSITY OF KENTUCKY

A meeting of the Student Branch of the University of Kentucky was held February 18. P. L. Kaufman of the class of 1901, who is at present employed by the Bascule Bridge Company, gave an interesting talk demonstrated with numerous drawings on the principle and construction of the bascule-bridge. He also devoted a part of his time to a discussion of the aeroscope at the Panama Pacific Exposition. This instrument was invented by Mr. Strouss and a detailed discussion of it has lately appeared in Engineering News.

UNIVERSITY OF MINNESOTA

A special meeting of the Minnesota Branch of the Society was held on February 25. Prof. S. C. Shipley of the Mechanical Engineering Department, University of Minnesota, gave a talk on Automobile Ignition Systems. He described first the early attempts at ignition by other means than the electric spark, and then the various modern ignition systems. The talk was illustrated by lantern slides. Because of the general interest of the subject to all engineers, the meeting was thrown open to all who cared to attend. There were forty-six people present.

In the Experimental Building on February 27, the Branch held a Get-together for all mechanical engineering students of the college and their friends. Prof. W. H. Kavanaugh, head of the Experimental Engineering Department, spoke of the history and achievements of the Am. Soc. M. E. Prof. J. V. Martenis, acting head of the Mechanical Engineering Department, gave an interesting description of a perpetual motion machine, about which his advice had been asked. J.

F. Colvin spoke of the purposes and aims of the Student Branch.

An open meeting of the Minnesota Branch was held March 4, in the Auditorium of the Main Engineering Building. Mr. Jackson of the Niagara Falls Carborundum Company gave a stereopticon lecture on the method and process of carborundum manufacture at the plant with which he is connected. He described in detail the power plant, the various departments of the manufacturing plant and their functions, and some of the many and varied uses to which carborundum products are put. The lecture was well attended.

UNIVERSITY OF MISSOURI

At a meeting of the University of Missouri Student Branch on February 18, I. O. Royse gave an interesting and scientific lecture on the gyroscope. He commenced with the history of the gyroscope, its first users and early applications. He then explained the general laws of the gyroscope as they were formulated by Foucault, and how they were made use of by Schlick and Brennen. With the aid of lantern slides, he showed many present day applications, for example, mono-rail cars, gyro-compasses, two wheeled automobiles and stabilizers for ships. The gyroscope forms the essential parts of the steering apparatus of torpedoes. He also discussed the gyroscopic effect of the fly wheels of motor cars and aeroplanes.

At a meeting on March 4, Mr. F. A. Heileman gave a talk on the Heating System of the University. He first explained heating systems in general, including everything from a fire place to the modern steam system, and showed how the various principles were made use of in the local institution. Some of the many automatic devices for regulating the steam pressure, eliminating the air and removing water from the heating systems were described, together with the consequences of ignorant or careless handling.

WASHINGTON UNIVERSITY

The Student Branch at Washington University has been fortunate throughout the present school year in having heard lectures on a variety of engineering subjects by men who are known, some of them perhaps only locally and some far and wide among engineers.

Among the speakers were Earl B. Morgan, Safety Engineer for the Commonwealth Steel Company, who gave an illustrated talk on The Safety Movement in the Industry and its Relation to the Engineer.

H. R. Setz, Chief Engineer Oil Engine Dept. Fulton Iron Works, St. Louis, Mo., delivered an illustrated lecture on Some Phases in the Development of the Diesel Engine. He had drawings of Diesel's first experimental engines and gave a complete account of the early history of the engine, explaining the difficulties experienced in trying to make the Diesel cycle practicable.

Dr. M. Von Recklinghausen whose system of water purification is much in use, even in the present European War, lectured before the Society on Ultra Violet Rays and their Application to Water Purification.

Dr. Thomas Watson, who assisted Graham Bell when he invented the telephone, gave a most interesting talk on his association with Graham Bell and the telephone.

WORCESTER POLYTECHNIC INSTITUTE

The Worcester Polytechnic Institute Branch held on February 19, a joint meeting with the Civil and Electrical Societies, to welcome home George H. Throop of the class of 1897, who addressed them on the subject of Public Utility Appraisals. Mr. Throop has been for some time with the J. G. White Company of New York City and was recently connected with the appraisal of the Pacific Gas and Electric Company's property, an immense system in California covering 40,000 square miles of territory. The speaker was in charge of the electric and street railway part of the work. His exposition of the various methods of figuring depreciation of plant and accessories was of particular interest to the seniors in the Mechanical Engineering course on account of the work in Shop Management. The lecture was illustrated with slides which showed the nature of the country, the power plants and transmission lines.

On March 5, there was an open meeting of the Branch. Invitations were extended to the members of the Worcester Automobile Club and their friends as well as to the general public. W. H. Weingar, representing the Maxwell Automobile Company, gave an interesting lecture on From Molten Metal to the Finished Automobile. The lecture was illustrated by several motion picture films, showing views of the factory and some outside points of interest.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 18th of the month.

POSITIONS AVAILABLE

057 Company selling engineering specialties wishes services of technical man familiar with power transmission machinery and having $5000 to invest. Apply through Society.

059 Mechanical engineer and chief draftsman in the engineering department of a large industrial concern. Prefer man who has had several years experience in design of coal and ore handling apparatus and its application, ore and slag crushers, blast and zinc furnaces; steel, brick and wood buildings, bridge work and general steam and power plant engineering. Name confidential, apply by letter.

068 Man capable of taking charge of tool department in manufacture of sterling silver hollow ware; one who understands generally, machine shop practice, but more particularly familiar with up-to-date methods of working sheet metal, such as rolling, cupping, drawing and spinning; have charge of laying out the tools to manufacture the goods and supervise the making of the tools and their operation. Any knowledge of up-to-date methods of shop practice of advantage. Position has good future for the right man. Salary will depend entirely upon what experience the man has had in this or a similar line. Location New England.

069 Steam specialty salesman who desires to take on a line of vacuum heating specialties. Representatives wanted in all the leading cities. Apply through Society.

070 High class designer on automatic machinery wanted for concern in South.

071 Competent machine tool designer with manufacturing experience in the design and maintenance of machine tool equipment of factory, manufacturing work in large quantities, on interchangeability of part system. Desires man to take charge of drafting force; essential that he have ample machine shop experience and be familiar with jigs, fixtures, turret and automatic screw machines, machines, etc. Location New York State. Apply through Society.

072 Young man, aggressive and possessed of initiative, wanted as assistant professor of electrical engineering. Must be first of all a teacher, but have had some practical experience. Location, New England. Apply through Society.

078 Position as works manager, government dock yard at Newcastle, Australia. Salary 750 pounds sterling, three years engagement. Exceptional opportunity. First-class rail and steamer transportation allowed. Apply through Society.

079 Factory manager for plant located in Cleveland, making parts for automobiles and employing normally six hundred men. Applicant must have experience in heavy and

light manufacturing machinery for automatic production, heat treating methods of metals, efficiency methods as to production and cost, and must be capable of handling men. State age, references and salary desired, or present salary. Apply through Society.

080 Opportunity desired for investment by man interested in engineering projects, who wishes to be associated in an established, "going concern" in construction or manufacturing enterprise where financial assistance would assure a managerial position. In position to secure investment interests of other parties. Name confidential. Apply through Society.

082 General superintendent to take full charge of works manufacturing cartridges. Name confidential. Apply through Society.

MEN AVAILABLE

D-41 Technical executive, mechanical engineer, young man, experienced in design and construction of special machinery, maintenance of property and engineering, construction and operation of power plants and buildings, high voltage transmission, etc. Past five years superintendent of plant department employing 225 men, desires to make change, with better opportunities. Present salary $4000 per year.

D-42 Associate-member, M.I.T. graduate, age 27, five years experience teaching, in factory and laboratory, desires to work through each department of factory with object of becoming assistant superintendent.

D-43 Graduate mechanical engineer, age 27, has worked as apprentice, in machine shop, draftsman, estimator and outside trouble man for large manufacturing concern, also efficiency man in food producing concern, desires position combining inside and outside work or as testing engineer.

D-44 Junior member, graduate mechanical engineer with post graduate course in hydraulic and water power engineering at M.I.T., employed for the past year in the State of Washington on hydrographic survey and river improvement work, desires position with company in hydraulic construction work. Location preferred western states.

D-45 Member, graduate mechanical engineer, University of Pennsylvania, eleven years experience in design and erection of hydraulic riveters and presses, steam hammers, steel mill machinery and elevator safeties, desires position as engineer or chief draftsman.

D-46 Member, expert on machine shop practice and modern tools, successful experience as superintendent of large shop, and sales manager of well known machine builders, would like to represent responsible concern in New York or Philadelphia. Salary or salary and commission.

D-47 Junior, age 26, unmarried, two years experience in cost and efficiency work, capable of producing results, desires position with firm contemplating installing efficiency methods for cost systems.

D-48 Member, graduate mechanical engineer, 20 years experience as designer and chief draftsman with leading manufacturers of simplex and duplex steam pumps, desires position.

D-49 Junior, technical graduate, experienced in hydraulics, steam, gas and oil engineering, three years in the tropics, sales work, general mechanical installation and operation, desires permanent connection with reliable firm.

D-50 Member, A.S.M.E. and S.A.E., age 37, thorough practical experience designing manufactured articles, laying out plants, designing and building special equipment and tools, inaugurating economical production and clerical systems, producing results, desires position offering a wider field than possible with present employers.

D-51 Junior, graduate M.E., who will very shortly complete a special apprenticeship with one of the largest railroad systems, desires position where this training will be of immediate value. Location immaterial.

D-52 Member, age 32, married, 15 years practical and executive experience in machine tool, automobile and gear manufacturing with representative concerns, now employed as superintendent, desires position along similar lines, or would take an interest in small firm having meritorious line to manufacture. Replies treated confidentially.

D-53 Junior, graduate M.E., four years experience in manufacturing and designing, desires similar position or along commercial line. At present in assistant executive position.

D-54 Junior, technical graduate in mechanical and electrical engineering, 12 years varied experience in design, construction, operation and maintenance of power houses and sub-stations; familiar with up-to-date methods of mapping and execution of construction and repair orders in power plant and mill accessories, experienced in testing and experimental work, possessing executive ability and pleasing personality, desires position of power engineer, assistant superintendent, assistant manager or works manager. At present employed. Location preferred, New York or vicinity.

D-55 Student member, age 23, graduating in June 1915 from Stevens Institute of Technology, experienced as draftsman, mechanic's helper on erection work, inspector of gas and water supplies, automobile repairs, and general office work in connection with railway association, desires any position which offers opportunity for advancement.

D-56 Engineer, with broad designing experience on metal working machinery and tools, is open for position. Can offer an improved design of machine in several sizes for a company wishing to extend their line. Location, middle West preferred.

D-57 Member, technical graduate, wide training and experience in design of power plants and machinery, construction, maintenance and operation, purchasing engineering material, executive charge of all consulting engineering work, including building construction of all kinds, desires position as works manager or superintendent.

D-58 Junior member, age 28, graduate mechanical engineer, five years practical experience, last two and one half years engineer of tests of large automobile company, desires position as assistant superintendent or engineer.

D-59 Mechanical engineer, Lehigh graduate 1912, three years experience in maintenance and equipment work, desires position. At present employed.

D-60 Member, age 35, technical graduate, married, 12 years experience in design, operation and construction of steam electric plants and purchasing equipment; specialist in fuel economy and fuels, desires position as mechanical or power plant efficiency engineer with company operating steam plant or chain of plants of large capacity in which better operating economy is desired. At present employed, but seeks position with chance for advancement.

D-61 Junior member, age 29, mechanical and electrical engineer, 12 years experience in design, construction, operation and maintenance of power plants of public utility and industrial corporations, having held positions as superintendent and chief engineer, and in charge of complete power tests, desires position with consulting engineer or large engineering corporation, or as power engineer for industrial corporation. Location immaterial.

D-62 Member, at present employed, but desiring greater opportunity, would consider position in engineering or designing department of concern requiring the services of a practical man with experience in elevator work. Location preferred, Eastern states.

D-63 Member with wide practical experience, fully acquainted with machine tool market, domestic and foreign,

travelled here and abroad, would like to represent first class firm in eastern territory; will travel if necessary. At present holding position as sales manager.

D-64 Member, engineering graduate, 14 years practical experience, four years as instructor in mechanical engineering, would consider position in well known engineering school or college. At present employed.

D-65 Associate-member, engineering graduate, six years teaching and four years general engineering experience, desires position for the coming academic year in mechanical department of a technical school.

D-66 Member, age 36, graduate M. E. of M. I. T., whose present position and previous work has required initiative, executive ability, tact, organization of men and the direction of their efforts along business lines as well as engineering. Experience also includes buying, selling, manufacture and construction work; familiar with office management, costs, keeping proper records and handling correspondence.

D-67 Associate member engaged at present in engineering sales line desires position as salesman or assistant sales manager.

D-68 Member, also Member Institution of Mechanical Engineers, for 16 years with exporters and importers of machinery, in charge of technical department in London and Tokyo, with wide experience in all technical and commercial work and in the American, European and Japanese markets; English, German, French correspondence, also some Spanish, requires responsible situation in similar capacity.

D-69 Junior, post-graduate M. E., Purdue University, age 31, nine years engineering experience in industrial management, has served successfully as special machine shop and foundry apprentice, staff engineer with production engineers of national reputation, superintendent of manufacturing; for last five years works manager, construction engineer on new works and equipment and plant manager for large manufacturers of mechanical goods and plated ware, desires position where experience would be of value. Available June first.

D-70 Mechanical engineer, age 33, with broad experience in the design and construction of water tube boilers, desires position in similar capacity, or as chief engineer or sales engineer.

D-71 Member, age 38, 16 years experience in mechanical, and structural work of great variety. Expert on economical and unique arrangements for handling coal, ore, ash and other materials; experience in economical plant lay outs and mill building design, wishes position with consulting, contracting engineer or industrial plant. Will take position at reduced salary till ability is proven.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

AMERICAN BOILER MANUFACTURERS ASSOCIATION OF THE UNITED STATES AND CANADA. Proceedings of 25th Annual Convention, 1913.

AMERICAN STANDARD FOR PIPE FLANGES, FITTINGS AND BOLTING FOR SAME. *New York, American Society of Mechanical Engineers, 1914.*

DIE ARBEITEN UND ERFINDUNGEN FABER DU FAURS AUF DEM GEBIETE DER WINDERHITZUNG UND DER GASFEUERUNG, by Eduard Herzog. *Halle a. S., 1914.*

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BROWN UNIVERSITY. Historical Catalogue, 1764-1904. *Providence, R. I., 1905.*

CARNEGIE ENDOWMENT FOR INTERNATIONAL PEACE. Signatures, ratifications, adhesions and reservations to the conventions and declarations of the first and second Hague peace conferences. (Pamphlet no. 3) *Washington, 1914.* Gift of Carnegie Endowment for International Peace.

CARNEGIE INSTITUTION OF WASHINGTON. Year Book, 1914. *Washington, 1914.* Gift of Institution.

CEMENT STUCCO. Bulletin no. 22, Association of American Portland Cement Manufacturers. *Philadelphia.* Gift of Association.

CENTRAL POWER STATION RATES. Legal opinion of Louis D. Brandeis. Gift of Uniform Electric Rate Association.

CHICAGO. DEPARTMENT OF PUBLIC WORKS. BUREAU OF ENGINEERING. Report Official Duty Test of Booster Pumps, Roseland Pumping Station, Chicago, Ill. *Chicago, 1914.* Gift of John Ericson.

CONCRETE SEPTIC TANKS. Gift of Association of American Portland Cement Manufacturers.

CONCRETE TANKS. Association of American Portland Cement Manufacturers. Bulletin no. 23. *Philadelphia.* Gift of Association.

COTTON WAREHOUSES AND TERMINAL OF THE STATE OF LOUISIANA. Built and operated by the Board of Commissioners of the Port of New Orleans. Gift of Ford, Bacon & Davis.

EDISON PHONOGRAPH WORKS, Report on fire, Dec. 9, 1914. Gift of Ira H. Woolson.

ELECTRIC RATES. An Analysis of Elements Entering into Cost of Service, P. R. Moses. Gift of Uniform Electric Rate Association.

ELEMENTS OF HYDRAULICS, S. E. Slocum. *New York, 1915.*

FEDERAL VALUATION OF RAILROAD PROPERTY, R. J. McCarty. *Kansas City, 1915.* Gift of author.

HEATING AND VENTILATING BUILDINGS, Rolla C. Carpenter. Ed. 6. *New York, John Wiley & Sons, 1915.* Gift of Publishers.

This edition has been largely rewritten and considerable new matter added. This edition brings the total issue up to twenty thousand. Especial attention is directed to the chapter on air-conditioning, summarizing recent papers on the subject before this society.
W. P. C.

DIE KESSEL UND MASCHINENBAUMATERIALIEN, Otto Hönigsberg, *Berlin, 1914.*

KÜHLMASCHINEN UND KÜHLEINRICHTUNGEN FÜR KRIEGS-UND HANDELSSCHIFFE, Eduard Reif. *Wittenberg, 1912.*

LEITFADEN FÜR DEN UNTERRICHT IN EISENKONSTRUKTIONEN AN MASCHINENBAUSCHULEN, L. Geusen, *Berlin, 1915.*

MINUTE ADOPTED BY THE RESEARCH CORPORATION IN RECOGNITION OF THE SERVICE RENDERED BY FREDERICK G. COTTRELL TO THE ADVANCEMENT OF SCIENCE. Jan. 15, 1915. Gift of C. W. Rice.

MOTOREN FÜR FLUGZEUGE UND LUFTSCHIFFE, Fritz Huth.. *Berlin, 1914.*

NATIONAL MARINE ENGINEERS' BENEFICIAL ASSOCIATION. Journal of Proceedings. vol. XIII, no. 2. *Washington, 1915.*

NATIONAL TUBULAR BOILER MAKERS' ASSOCIATION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS AND AMERICAN ASSOCIATION OF STEEL MANUFACTURERS. Minutes of Joint Meeting of Committee, June 15, 1914.

NEW YORK CITY. BOARD OF ESTIMATE AND APPORTIONMENT. Monthly bulletin of tests made in laboratories conducted by the City of New York upon samples taken from deliveries of materials and supplies to City Departments. *November 1914.* Gift of Board of Estimate and Apportionment.

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SOUTHERN AND SOUTHWESTERN RAILWAY CLUB. Proceedings, Nov. 1895. Gift of Railroad Branch Young Men's Christian Association.

SPERRY GYRO-COMPASS AND NAVIGATION EQUIPMENT. Ed. 2. *New York, 1912.* Gift of Elmer A. Sperry.

STEAM BOILER EXPLOSIONS, W. H. Boehm. Lecture delivered at Cornell University, May 3, 1912.

DIE STELLUNG DER DEUTSCHEN MASCHINENINDUSTRIE IM DEUTSCHEN WIRTSCHAFTSLEBEN UND AUF DEM WELTMARKTE, Fr. Frölich. *Berlin, 1914.*

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UTILIZATION OF SOLAR ENERGY, A. S. E. Ackermann. Reprinted from Transactions of Society of Engineers, 1914. Gift of author.

GEORGE WESTINGHOUSE, 1846-1914, BIOGRAPHY, Arthur Warren. Gift of Arthur Warren.

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GIFT OF BUREAU OF RAILWAY ECONOMICS

THE DEADLY TOLL OF TRESPASS ON RAILWAYS. Railway Business Association Bulletin no. 16. *Jan. 27, 1915.*

SOME POLITICAL PHASES OF GOVERNMENT OWNERSHIP, Samuel O. Dunn. Reprinted from The Atlantic Monthly, Feb. 1915.

FRED WARREN. A PROBLEM FOR TWO NATIONS. Address to the Alumni Association of the Massachusetts Institute of Technology, Howard Elliott, Boston, Jan. 9, 1915.

GIFT OF JOHN PHILP

The library of the late Horace See, former President of the Society. The collection is particularly strong in sets of periodicals and works on naval architecture. This is one of the most important additions to the Library made in recent years.

EXCHANGES

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION. Proceedings, vol. 11, pts. 1-2; vol. 12, pts. 1-3; vol. 13. *v. p. 1910-12.*

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal